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Surge Analysis in Mobile Harbor, Alabama

Ship-Simulation Report

Morgan M. Johnston, Kiara I. Pazan, Yan Ding, Mary Claire Allison, and Sung-Chan Kim

September 2023



Coastal and Hydraulics Laboratory

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US Army Engineer Research and Development Center
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Final report

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Prepared for US Army Corps of Engineers, Mobile District
PO Box 2288
Mobile, AL 36628-0001

Under Funding Account Code U4379870; AMSCO Code 076126

Abstract

A navigation channel improvement study for Mobile Harbor was conducted by the US Army Corps of Engineers, Mobile District (CESAM), and the Alabama State Port Authority. The US Army Engineer Research and Development Center (ERDC) assisted CESAM in assessing channel modifications using ERDC's Ship/Tow Simulator through a Feasibility Level Screening Simulation study in 2017 and through a more comprehensive ship-simulation study in 2020. During the 2020 study, a safety concern was identified related to vessel interactions between a transiting vessel passing docked vessels at the McDuffie Coal Terminal located along the main federal channel. In the previous ship-simulation studies, the docked vessels were represented as targets, which means the ships are visually represented but no hydrodynamic interaction is captured. To fully assess this interaction, a surge-analysis study was completed in 2022 that used hydrodynamic models to represent docked vessels with representative mooring conditions. This study assessed several proposed navigation channel expansions across from the McDuffie Coal Terminal over the course of six testing days with four pilots. Assessment of the proposed modifications was accomplished through analysis of ship simulations completed by experienced local pilots, track plots, run sheets, and final pilot questionnaires.

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Preface

This study was conducted for the US Army Corps of Engineers, Mobile District (CESAM), under Funding Account Code U4379870; AMSCO Code 076126. The technical lead at CESAM was Ms. Elizabeth Godsey. The project manager was Mr. David Newell.

The ship-simulation portion of this project was completed by the US Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL), Navigation Branch of the Navigation Division. The numerical modeling portion of this project was completed by the ERDC-CHL, Coastal Processes Branch of the Flood and Storm Protection Division. At the time of this study, Mr. Ben Burnham was chief of the Navigation Branch, Mr. Victor M. Gonzalez was chief of the Coastal Processes Branch, Ms. Ashley Frey was chief of the Navigation Division, and Dr. Cary Talbot was chief of the Flood and Storm Protection Division.

At the time of publication of this report, the deputy director of CHL was Mr. Keith Flowers, and the director was Dr. Ty V. Wamsley.

COL Christian Patterson was the commander of ERDC, and the director was Dr. David. W. Pittman.

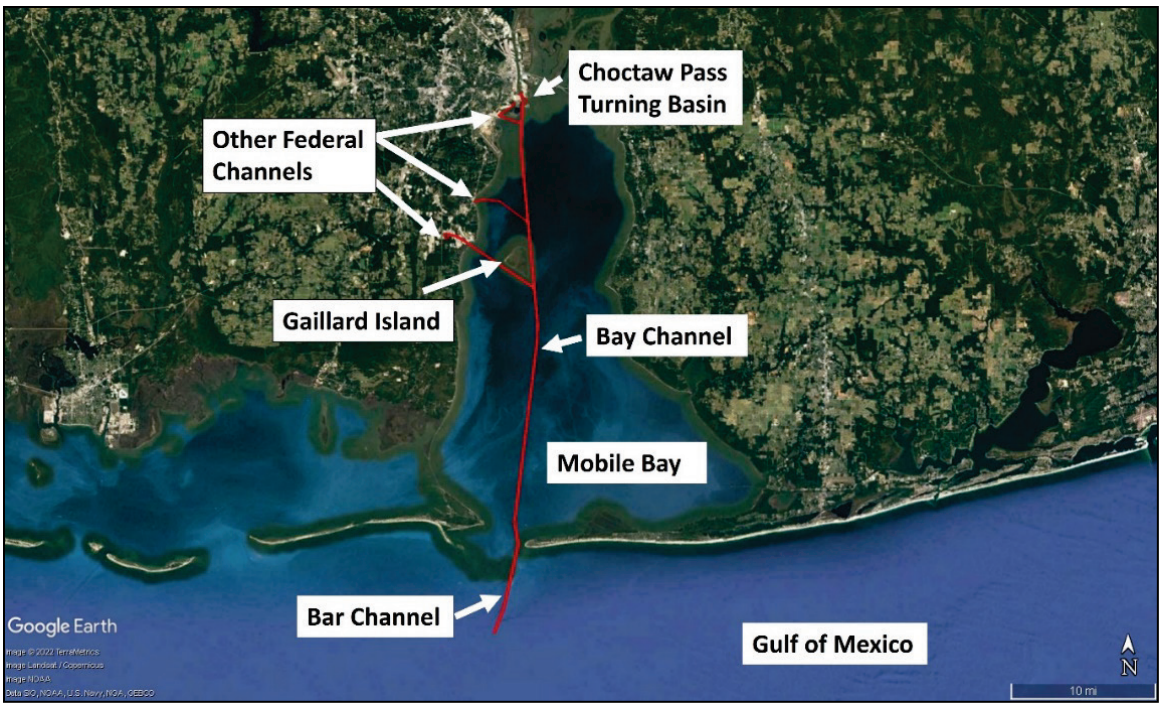
1 Introduction

1.1 Background

Mobile Bay estuary connects the southwest corner of Alabama to the Gulf of Mexico and extends approximately 413 square miles. The federal channels comprise a small portion of the overall bay, as shown in Figure 1. The bay has an average depth of approximately 10 ft.* Several rivers drain into the northern section of the bay, including the Mobile and Tensaw Rivers. Over recent years, the Port of Mobile has experienced an increase in traffic volume and calls from larger vessels. Based on the existing channel dimensions, some of the larger vessels experience traffic inefficiencies due to delays. These delays include restrictions of only one-way traffic and waiting for ideal conditions to safely transit the channels, such as limited current or during daylight. The current depth of the channel also limits the cargo capacity of larger vessels calling on the port. As the shipping industry continues to expand, it is expected that these inefficiencies will increase based on the current channel dimensions. A navigation improvement study was conducted for Mobile Harbor to determine the modifications necessary to better utilize the harbor and reduce these concerns. Further information regarding the navigation improvement investigation can be found in the final general evaluation report (USACE SAM 2019).

* For a full list of the spelled-out forms of the units of measure and unit conversions used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office 2016), 248–52 and 345–7, respectively. https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-016.pdf.

Figure 1. Mobile Bay.



1.2 Previous Ship-Simulation Studies

1.2.1 Reconnaissance

In August 2016, US Army Engineer Research and Development Center (ERDC) personnel performed a reconnaissance visit to Mobile Harbor to inform an initial Feasibility Level Screening Simulation (FLSS) study. ERDC and US Army Corps of Engineers (USACE), Mobile District (SAM), personnel rode several deep draft vessels in Mobile Harbor over the course of a few days (Figure 2). During these transits, digital images were captured to create the visual database for the ERDC Ship/Tow Simulator (STS). The reconnaissance visit also allowed for navigation conditions in Mobile Harbor to be observed and discussions with the Mobile Bar Pilots to occur.

Figure 2. Image taken onboard vessel in the Mobile Harbor during the 2016 reconnaissance trip.



1.2.2 Feasibility Level Screening Simulation (FLSS) Study

An FLSS study was completed on 23–25 May 2017 at the ERDC STS to screen channel modifications in Mobile Harbor. An FLSS study focuses on screening proposed design alternatives using lower resolution databases. This type of study allows for preliminary insight to be gained regarding channel feasibility with reduced monetary and time commitments. The FLSS testing focused on assessing various passing-lane dimensions, passing-vessel combinations, bend modifications, and turning-basin-design alternatives. One of the modifications included only deepening (no widening) the Choctaw Pass Turning Basin. However, during the study, it was determined that the turning basin would also need to be widened to accommodate the design vessel. The databases developed for the FLSS study were used as a foundation for both the 2020 study and 2022 study.

Further description of the FLSS study can be found in the final general evaluation report (USACE SAM 2019).

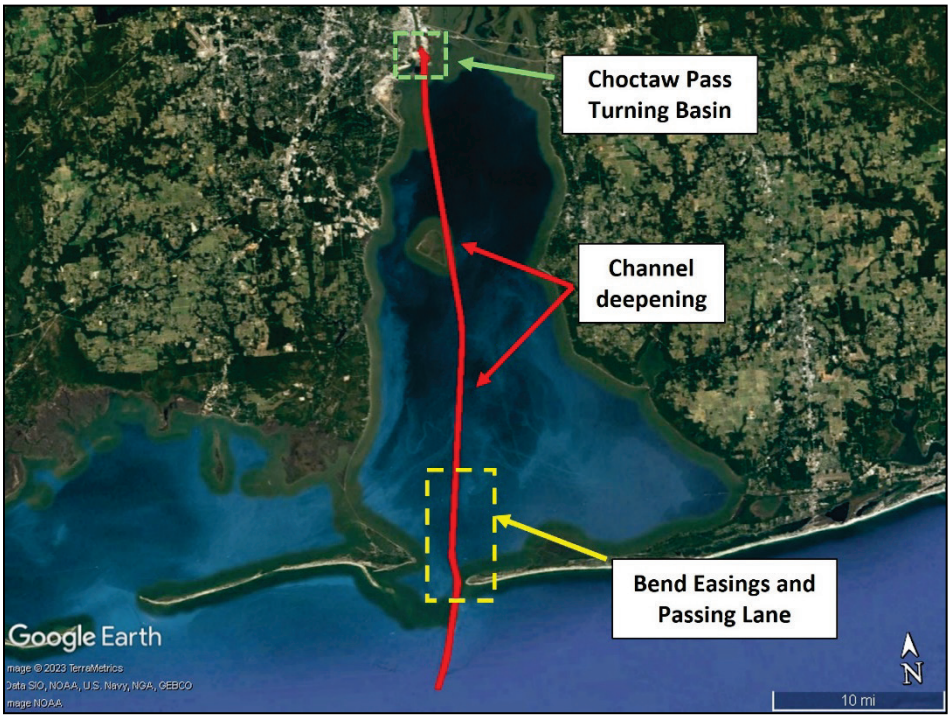
1.2.3 Full Ship-Simulation Study

In 2020, a ship-simulation study was performed at the ERDC STS to evaluate proposed Mobile Harbor channel modifications for the US Army Corps of Engineers, Mobile District (CESAM). Ship simulations for Mobile Harbor were conducted with 10 pilots in March 2020 and July 2020. More information regarding the study and its results can be found in ERDC/CHL TR-21-17 (Johnston et al. 2021).

During this study, several modifications to the federally maintained ship channels in Mobile Bay were tested. These modifications included

- deepening the Bar Channel, Bay Channel, and a small section of the River Channel (located north of the Choctaw Pass Turning Basin),
- minor bend easings in the northern section of the Bar Channel,
- increased channel width for a 3-mile passing lane in the lower Bay Channel, and
- an expansion to the Choctaw Pass Turning Basin (Figure 3).

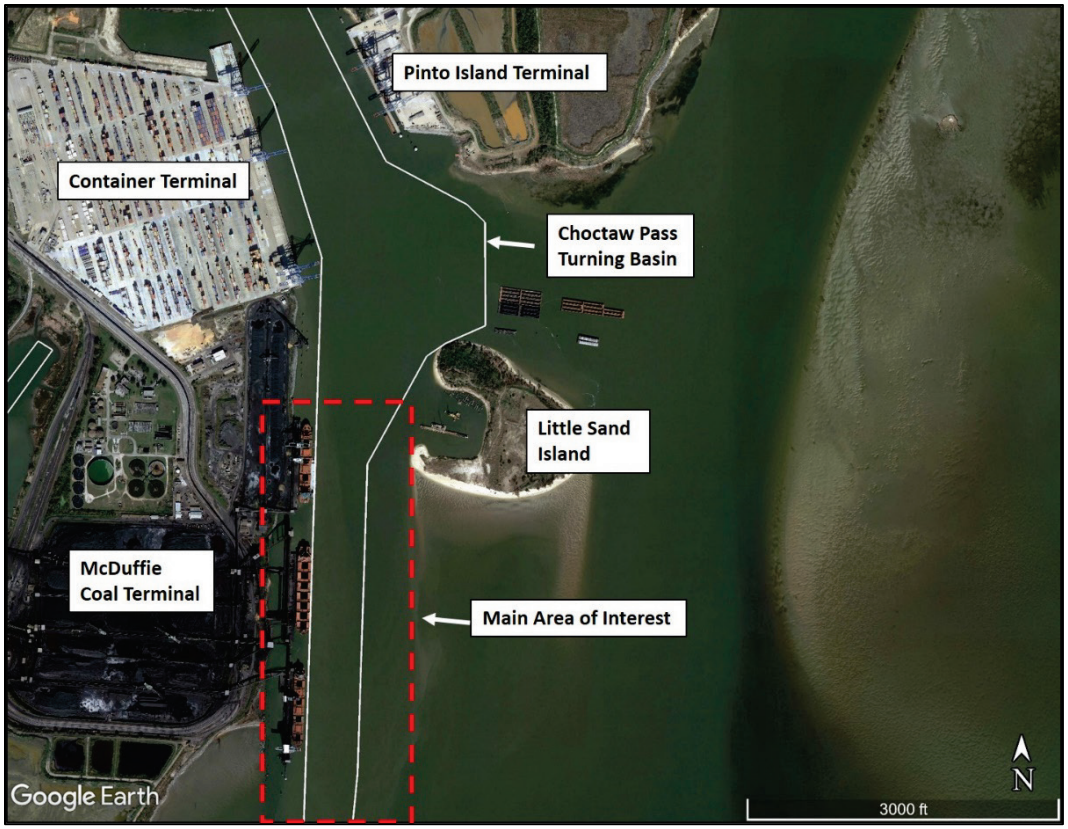
Figure 3. Areas of interest in Mobile Bay.



1.3 Purpose

During the 2020 study, a safety concern was identified in the channel adjacent to the McDuffie Coal Terminal and near the entrance to the Choctaw Pass Turning Basin. The McDuffie Coal Terminal berths are located along the main federal channel (Figure 4). Vessels transiting by berthed vessels at the McDuffie Coal Terminal must travel at slow speeds to avoid disturbing the docked vessels. Pilots currently suggest transition at speeds less than 6 kn. However, some speed must be preserved to maintain steerage during various environmental conditions (current and wind). There have been historic events where dock damage has occurred due to a passing vessel and a berthed vessel interacting (Elizabeth Godsey, email to author, 19 November 2020). Since deeper-draft vessels are expected to call on the port following the channel modifications, it is expected that the interactions occurring between vessels would increase. While this area was tested during the ship simulations performed in 2020, the docked vessels were represented as targets, which provide only visual cues for the pilots. Vessel interaction and movement of the docked vessels were not simulated or captured in the study. Representing docked vessels as targets is typical for ship-simulation studies because full hydrodynamic models require additional data and longer simulation set up time. Due to this identified concern, a channel expansion was suggested and a follow-on ship-simulation study was recommended to focus on the Choctaw Pass Turning Basin entrance and vessel interactions.

Figure 4. Terminals near the Choctaw Pass Turning Basin.



1.4 Objective

The purpose of this study was to use the ERDC STS to test the proposed navigation channel expansion across from the McDuffie Coal Terminal and near the entrance to the Choctaw Pass Turning Basin. Channel-expansion alternatives were evaluated based on the movement of moored vessels induced by passing vessels and the distance and speed of the passing vessel. During this study, docked vessels were represented as full hydrodynamic models so that an understanding of vessel interactions between a transiting vessel and docked vessels could be gained. Docked-vessel movement (surge and sway) was tracked throughout each simulation to understand if movement thresholds were exceeded.

1.5 Approach

Since vessel handling in ports is highly specialized, it is vital that local pilots be identified to pilot the vessels during testing. Ship-simulation testing of Mobile Harbor was conducted with four Mobile Bar Pilots over six testing days at the ERDC STS facility in Vicksburg, Mississippi. To

accommodate sponsors who cannot travel to the ERDC STS facility for testing, the ERDC STS can provide some participation virtually. This includes streaming of the operator instructor station for one of the bridges and the ability to call in during debrief sessions. Table 1 is a list of all the non-ERDC attendees present during testing. Validation of ERDC STS databases occurred on 9–11 February 2022. Testing occurred during 11 February 2022, and 16–18 February 2022. The validity of the proposed changes was analyzed through a series of ship-simulation exercises, track plots (Appendix A), discussions following simulations, written pilot comments (Appendix A), final wrap-up discussions, and final pilot questionnaires (Appendix B).

Table 1. List of attendees present for ship-simulation testing.

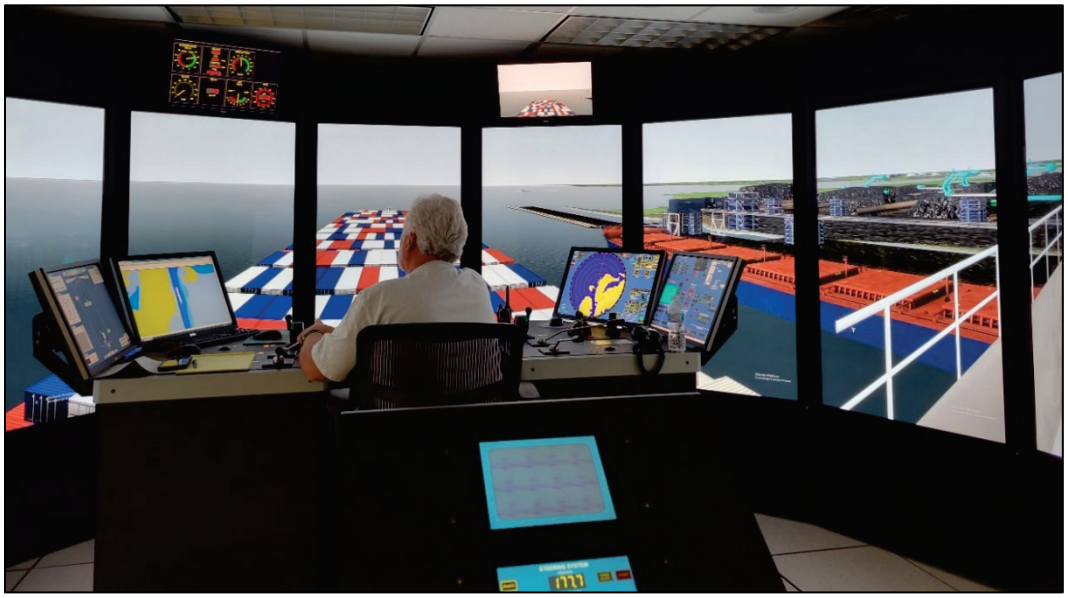
Name	Pilot ID #	Dates Attended
Captain Curtis Wilson	1	9–11 February 2022
Captain David Berault	2	9–11 February 2022
Captain Pete Burns	3	16–18 February 2022
Captain David Bender	4	16–18 February 2022
Mr. John Bass, Jr.–CESAM	na	17 February 2022
Ms. Ashley Throop–CESAM	na	17 February 2022
Mr. N. Stephen Caldwell–CESAM	na	17 February 2022
Ms. Elizabeth Godsey–CESAM	na	11, 16–18 2022 February (virtual)

1.6 US Army Engineer Research and Development Center (ERDC) Ship/Tow Simulator (STS) Description

Since the 1980s, the USACE has used the ERDC STS as a channel-assessment tool for navigation projects. The ERDC STS has three full-mission bridges that operate in real time. Each bridge replicates a real vessel bridge and contains hardware that the pilot can use to control the vessel, including rudders, thruster, engine power, and tug commands. The vessel bridges are controlled by local pilots while the simulation conditions

(wind, weather, lighting, current, etc.) are controlled by ERDC STS operators. If a simulation features tugboats, the pilots typically provide the tug commands, and the tug forces are controlled by ERDC STS operators. However, tugboats can be controlled in a bridge if a tow pilot is available. For this study, the tugboats were operator controlled by ERDC STS team members. Figure 5 shows a captain piloting a containership headed outbound from the Choctaw Pass Turning Basin in one of the bridges of the STS. These bridges can operate independently or can be linked together such as in a passing situation. The ERDC STS also has eight virtual bridges that allow for appropriate hydrodynamic calculations; however, the virtual bridges are not connected to the hardware in a full-mission bridge. These vessels models are controlled via the operator station if utilized. A virtual database is created for existing and proposed conditions for each unique project location. A virtual database includes input such as wind, waves, currents, bathymetry data, navigational markers, and a visual scene.

Figure 5. Captain piloting the Ship/Tow Simulator (STS) during testing.



2 Proposed Modifications

Following the 2020 study, three channel expansions were recommended for testing: +50 ft (Project Alternative 2, or P2), +100 ft (P3), and +150 ft (P4) (Figure 6). The distances in feet (+50, +100, +150) are measured east from the straight section of the existing channel opposite of the McDuffie Coal Terminal (Figure 7). The southern connection with the original channel occurs just above the Arlington Channel. Following the first set of simulations (9–11 February 2022), the recommended channel-expansion designs were modified based on pilot input. Pilots expressed that the entrance to the channel expansion was too abrupt and they were not able to fully utilize the expansion until approaching McDuffie Coal Terminal #2. Based on the pilots' feedback, the alternatives were modified to extend the expansion farther south and ease the southern approach toward Arlington Channel. The modified alternatives tested in the second set of simulations (16–18 February 2022) were +50 ft (P2A), +100 ft (P3A), +150 ft (P4A), and +75 ft (P75) (Figure 8). Since these modifications were minor and simulation testing time was limited, the hydrodynamics were not rerun for the modified channel designs.

Figure 6. Original channel expansion alternatives.

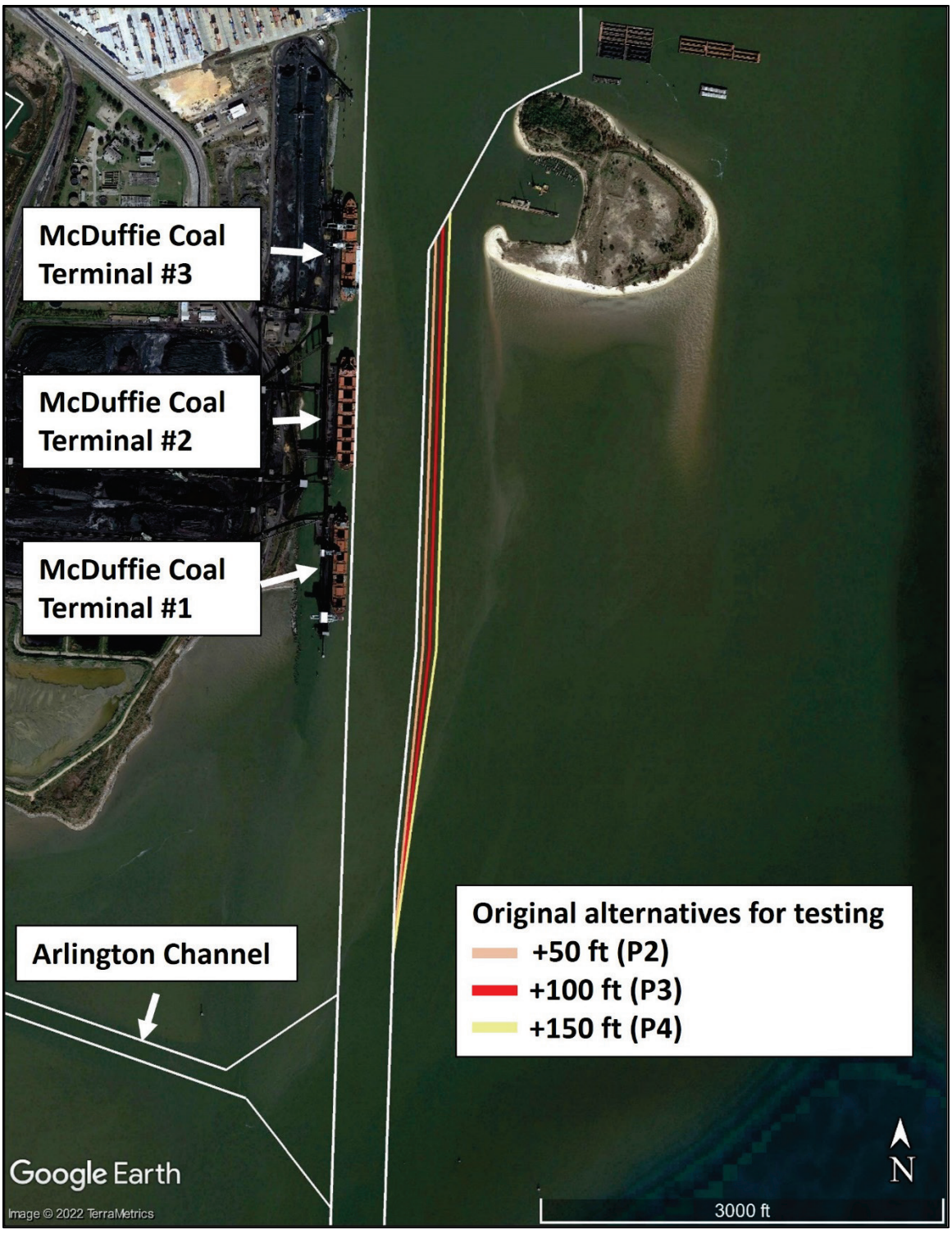


Figure 7. Example of distances used to define alternatives.

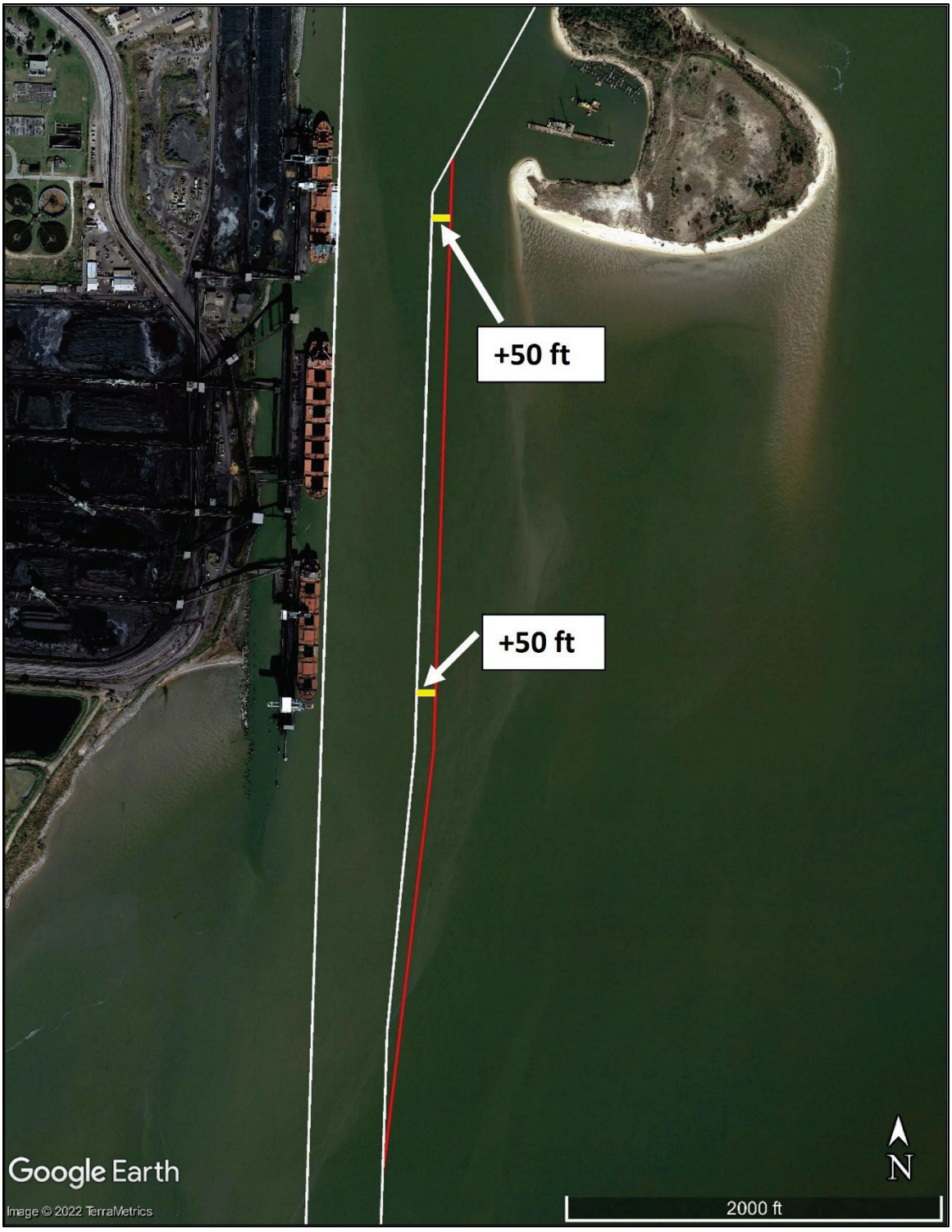
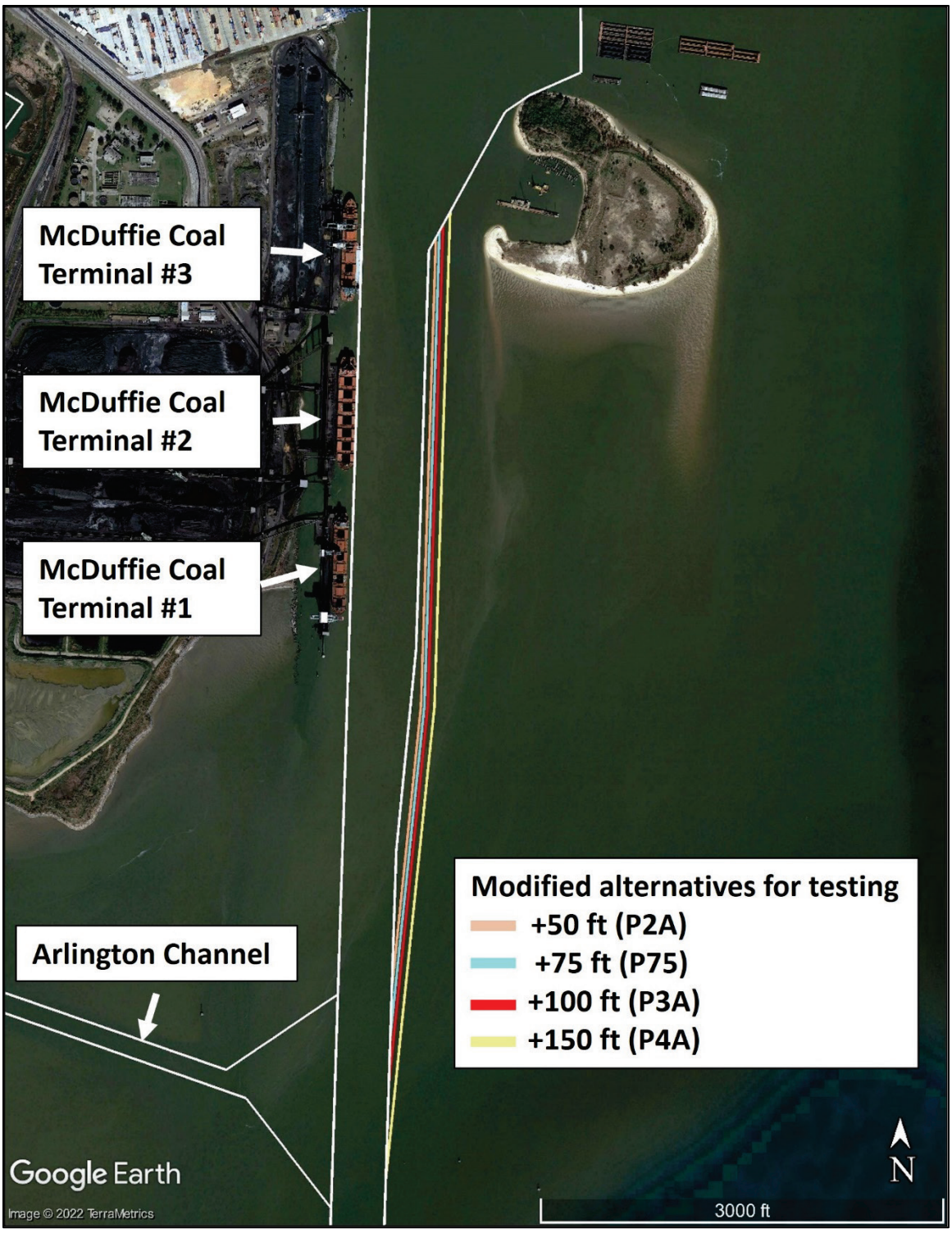


Figure 8. Modified channel expansion alternatives.



3 Hydrodynamic Modeling for the Ship Simulator

3.1 Simulation Model and Procedure

Hydrodynamic simulations were performed to provide input into ship simulator by using the Advanced Circulation (ADCIRC) model*. ADCIRC is a numerical model for simulating shallow-water flows governed by the shallow-water equations that provide numerical solutions of spatiotemporal variations of water-surface elevations and depth-averaged flow velocities (e.g., Luettich and Westerink 2004). The model can consider various hydrodynamic driving forcing such as tides, river flows, winds, the Coriolis force by Earth's rotation, and bottom friction. ADCIRC employs the finite element method to solve the nonlinear shallow water equations on a triangular mesh, with boundary conditions of water surface elevations (tides) at open sea and inflow rates from tributaries.

Therefore, a general procedure for performing a simulation using ADCIRC consists of

- generation of a triangular mesh covering a study water body (the Mobile Bay) and resolution of the details of geometrical features of structures (docks, dikes, etc.), navigation channels, water edges, islands, and river courses;
- configuration of an ADCIRC model by specifying boundary conditions of water elevations and river inflows (from the Mobile River and the Middle River at the upstream of the Mobile Harbor);
- generation of wind conditions by giving wind speeds at two horizontal directions that are defined at mesh nodes; and
- generation of a nodal attribute file by giving model parameters such as bottom friction coefficients, eddy viscosity, and others.

* Bunch, B., E. Hayter, S. C. Kim, E. Godsey, and R. Chapman. 2021. *Three Dimensional Hydrodynamic, Water Quality, and Sediment Transport Modeling of Mobile Bay*. ERDC/EL LR-21-3. Vicksburg, MS: US Army Engineer Research and Development Center, Environmental Laboratory.

3.2 Mesh Development for Existing Conditions and Project Conditions

A triangular grid for the existing conditions was developed to simulate flows under the present conditions in navigation channels, harbors, terminals, and rivers. Since the channel modifications proposed near the Choctaw Pass Turning Basin were small, it was important to have small mesh resolution to capture those modifications. The grid for this study was generated by refining the grid from a coarse ADCIRC grid (Johnston et al. 2021) in several focus areas. These focus areas included the Mobile ship channels, the Choctaw Pass Turning Basin, and the vessel terminals. This original coarse grid was used to provide currents for the 2020 ship-simulation study. The mesh properties of the coarse and refined grids are provided in Table 2. The refined grid has greater spatial resolution in the focus areas, with a grid size 2 to 3 times finer than the coarse grid. The vertical datum of depths in all the ADCIRC grids for this study is MLLW (mean lower low water) level. Figure 9 through Figure 11*a* depict the refined ADCIRC triangular mesh for the existing condition over the whole domain, the Mobile Bay and vicinity, and the Mobile Harbor and vicinity, respectively.

Figure 11*b* gives a close-up view of the original coarse grid for comparison to the present refined grid on Figure 11*a*. These figures on the refined grids show the transformation of higher resolution from the focus area to the offshore, which includes Mobile Harbor and the navigation channel. The water depths, relative to the MLLW, for the areas of the Mobile Bay, the Harbor, and the bay entrance are presented in Figure 12*a*, *b*, and *c*, respectively. The water depth in the Choctaw Pass Turning Basin and the navigation channel (Figure 12*b* and *c*) is set to 48 ft based on the hydrographical survey collected in 2016.

Table 2. Quality of two Advanced Circulation (ADCIRC) meshes. (Johnston et al. 2021. Public domain.)

Variables	Previous (coarse) Grid	Refined Grid
Number of nodes	174,954	189,745
Number of elements	329,891	359,159
Spatial resolution of the grid in the Choctaw Pass Turning Basin (ft)	140.0 to 160.0	65.0 to 72.0
Spatial resolution in the Mobile ship channels (ft)	170.0 to 280	70.0 to 90.0

Figure 9. The Advanced Circulation (ADCIRC) mesh covering the entire computational domain.

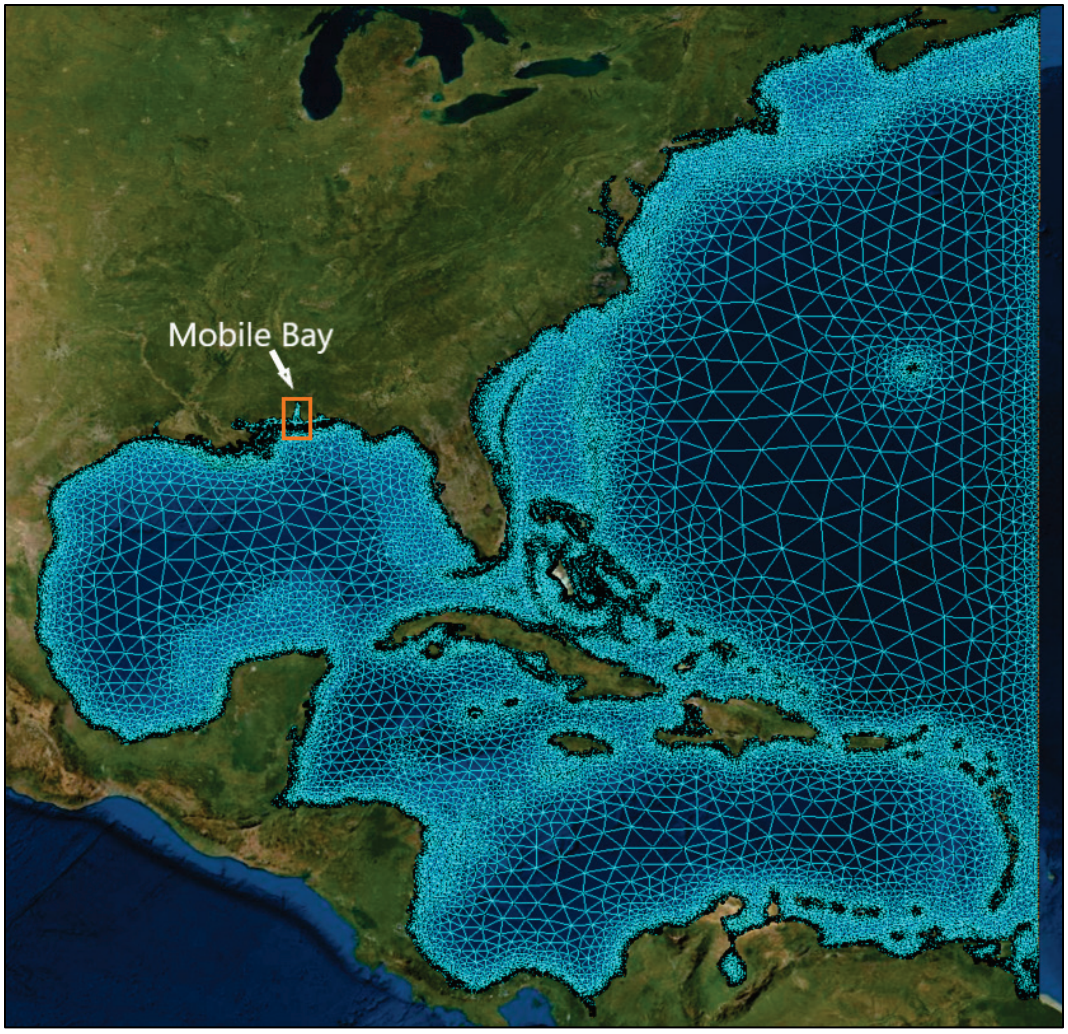


Figure 10. The Mobile Bay and vicinity from the refined ADCIRC model grid for existing conditions.



Figure 11. The upper Mobile Bay and the entrance to the Mobile River portion of the ADCIRC grids.

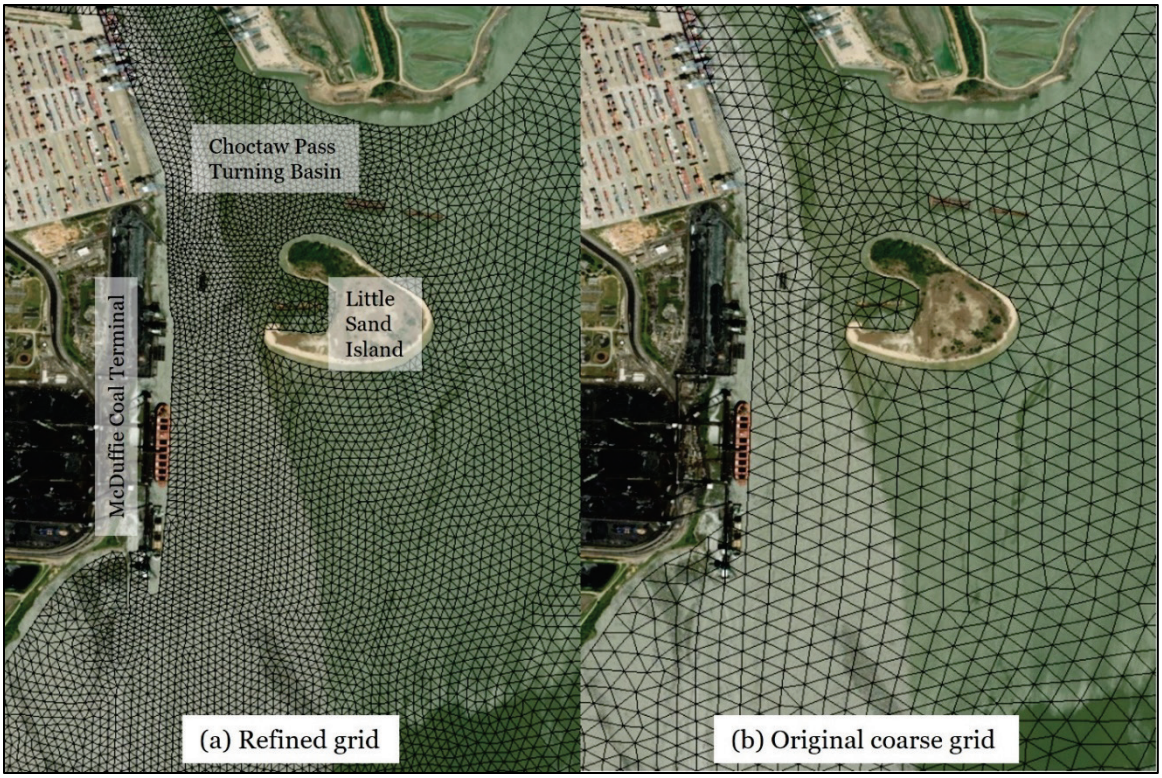


Figure 12. ADCIRC grid and water depth (ft) relative to mean lower low water (MLLW) in (*a*) Mobile Bay, (*b*) the Mobile Harbor and vicinity, and (*c*) the entrance of the Mobile Bay and the bar channel.

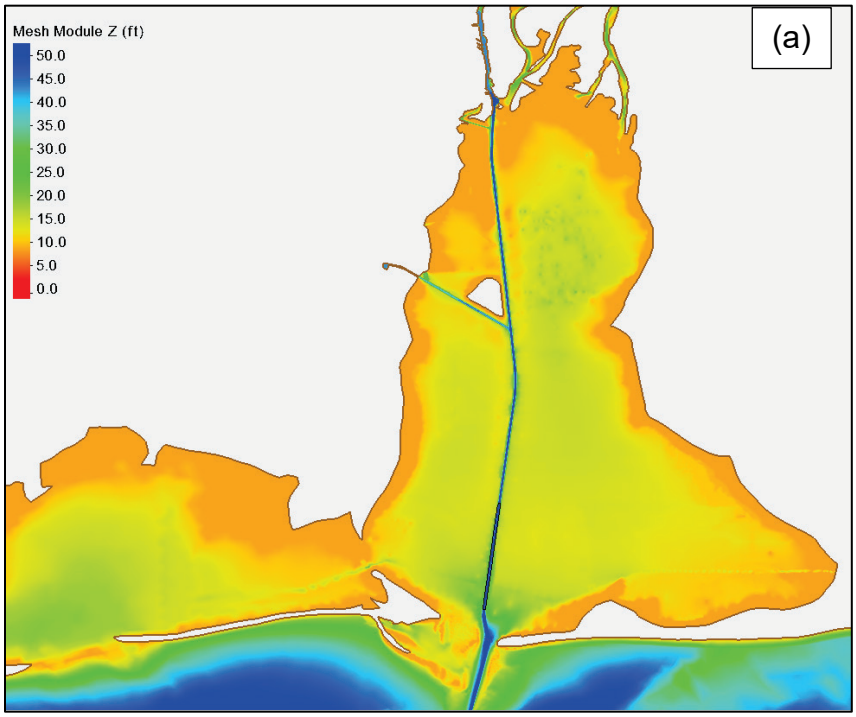
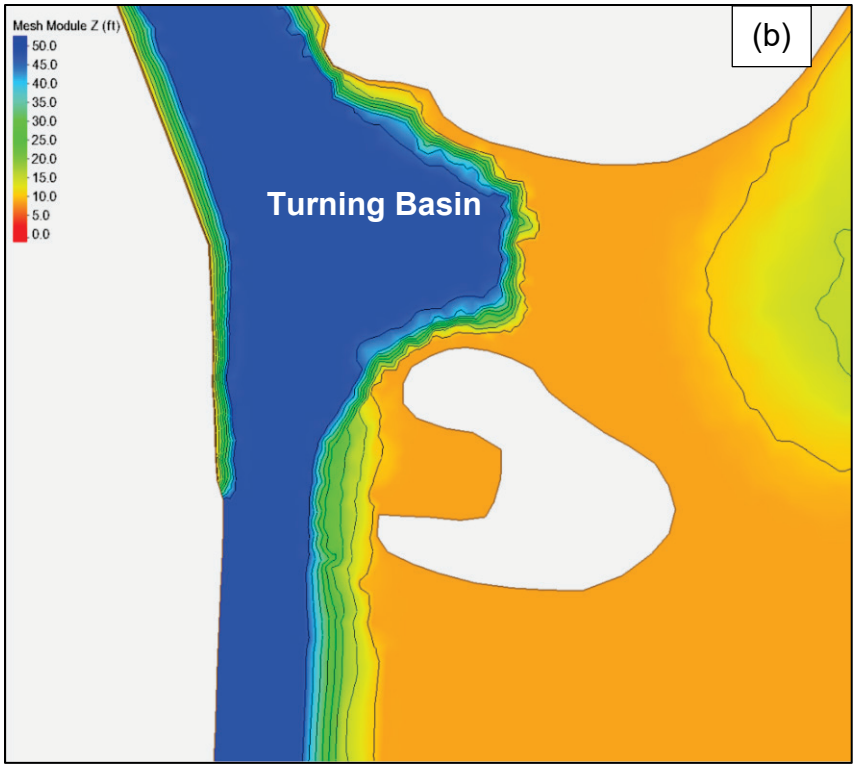
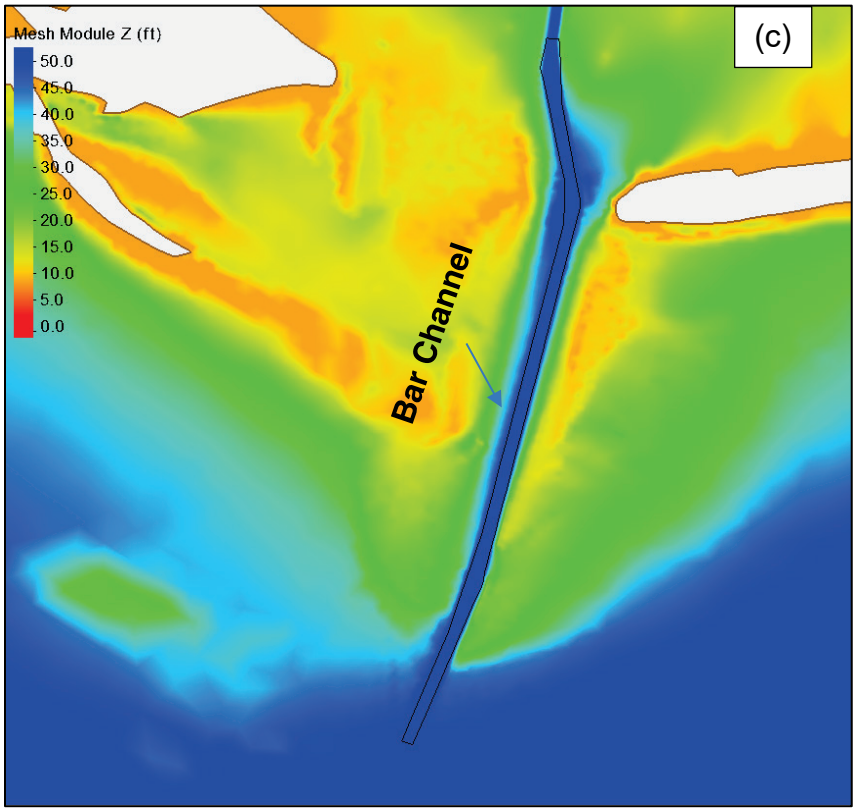


Figure 12 (cont.). ADCIRC grid and water depth (ft) relative to mean lower low water (MLLW) in (*a*) Mobile Bay, (*b*) the Mobile Harbor and vicinity, and (*c*) the entrance of the Mobile Bay and the bar channel.





Numerical simulations were performed to consider one existing-condition and three project conditions. The project conditions for improving the Mobile Harbor, ship channels, and the terminal primarily include four project modifications: (1) extension of the Choctaw Pass Turning Basin, (2) McDuffie Coal Terminal widening, (3) ship-channels deepening and widening, and (4) the Mobile ship-channels deepening and widening (Figure 3). Modifications 3 and 4 were not testing in the ERDC STS during this study. A summary of the four simulation conditions is presented in Table 3.

Table 3. Project conditions in ADCIRC model simulations.

ADCIRC Model-Simulation Condition	Choctaw Pass Turning Basin Extension and Deepening	McDuffie Coal Terminal Widening	Ship-Channels Deepening	Bar-Channel Deepening
Existing Condition	na (or status quo)	na	na (or status quo) (48 ft)	approximately 50 ft
Project No. 1	With extension and 50 ft deepening	150 ft	50 ft	52 ft
Project No. 2	With extension and 50 ft deepening	100 ft	50 ft	52 ft
Project No. 3	With extension and 50 ft deepening	50 ft	50 ft	52 ft

The project conditions are laid out on georeferenced shapefiles, as shown in Figure 13. The shaded area around the Choctaw Pass Turning Basin is the extended water area with 1V:5H side slopes, which results in the removal of a portion of the Little Sand Island. The lines aligned on the E side of the McDuffie Coal Terminal are the three widening boundaries with an equal space of 50 ft.

The three new ADCIRC meshes for the three project conditions were developed based on the grid for the existing condition (i.e., Figure 10 and

Figure 11). The meshes and water depths relative to MLLW are shown in Figure 14 (*a*) Project No. 1, (*b*) Project No. 2, and (*c*) Project No. 3. Note that the water depth in the channel and the area of Turning Basin is 50 ft and the island is reshaped to fit the need of the 250 ft Turning Basin widening.

Figure 13. Layouts (shapefiles) of project conditions.

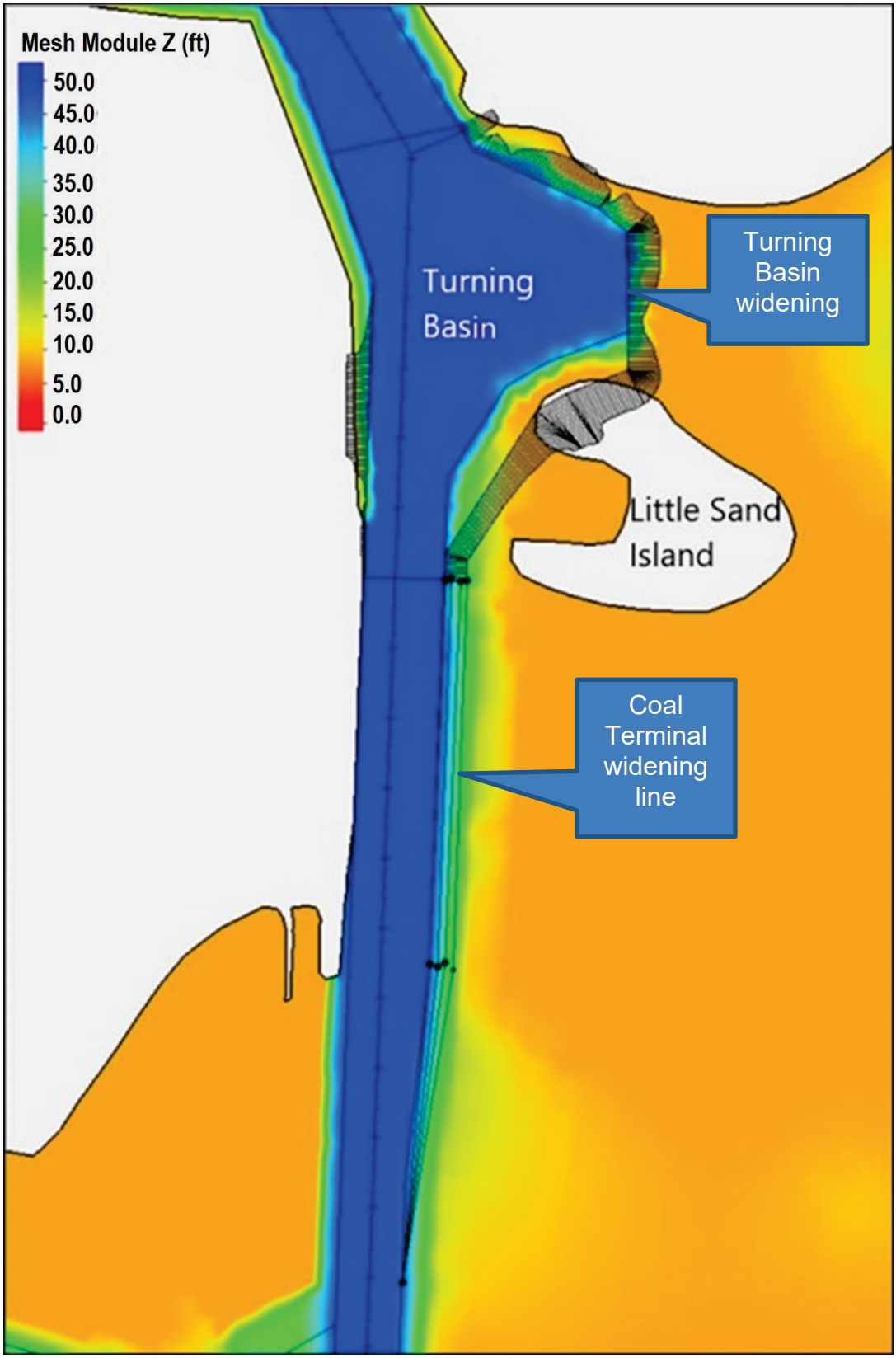


Figure 14. Mesh around the turning basin and Little Sand Island for the three project conditions: (*a*) Project No. 1, (*b*) Project No. 2, and (*c*) Project No. 3.

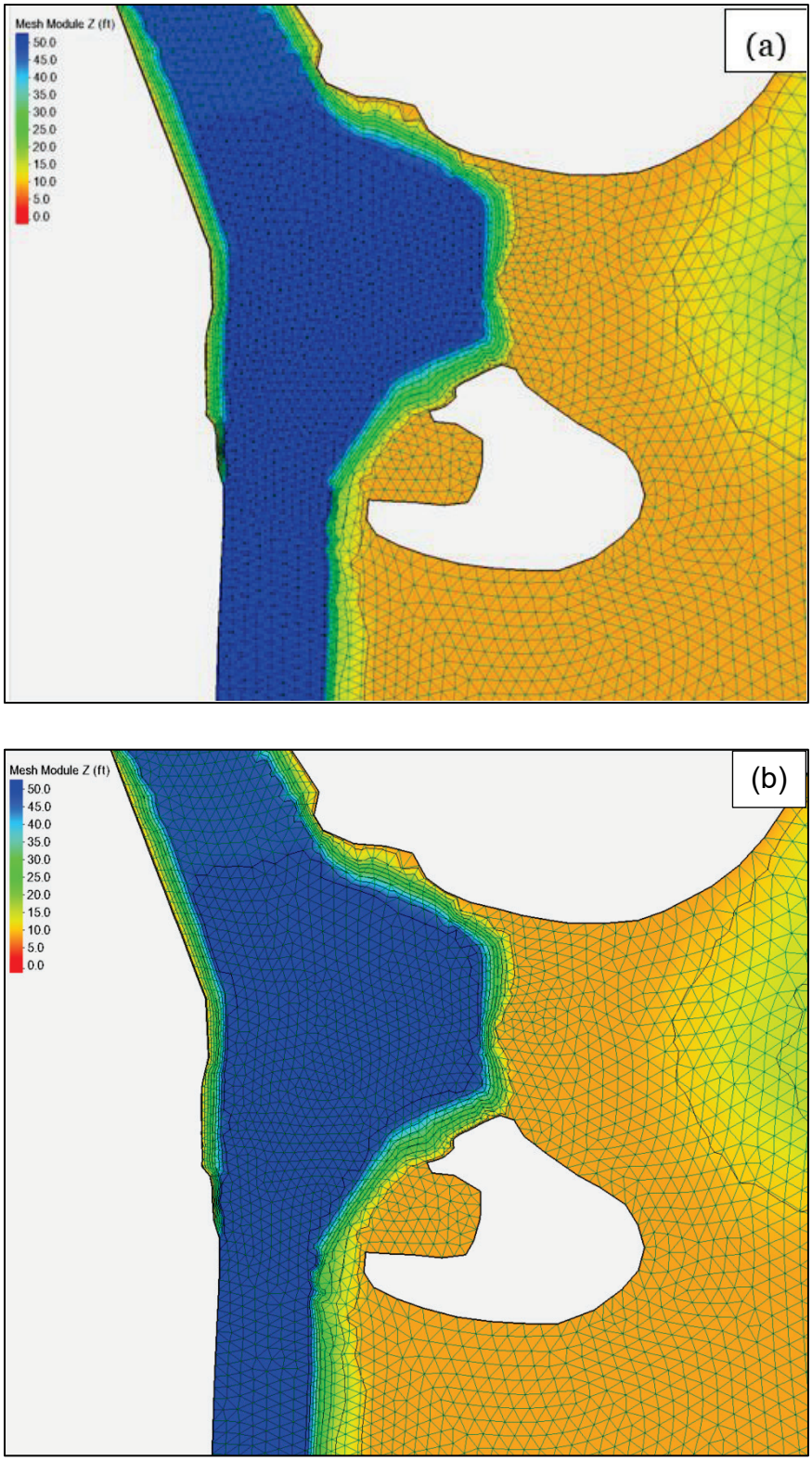
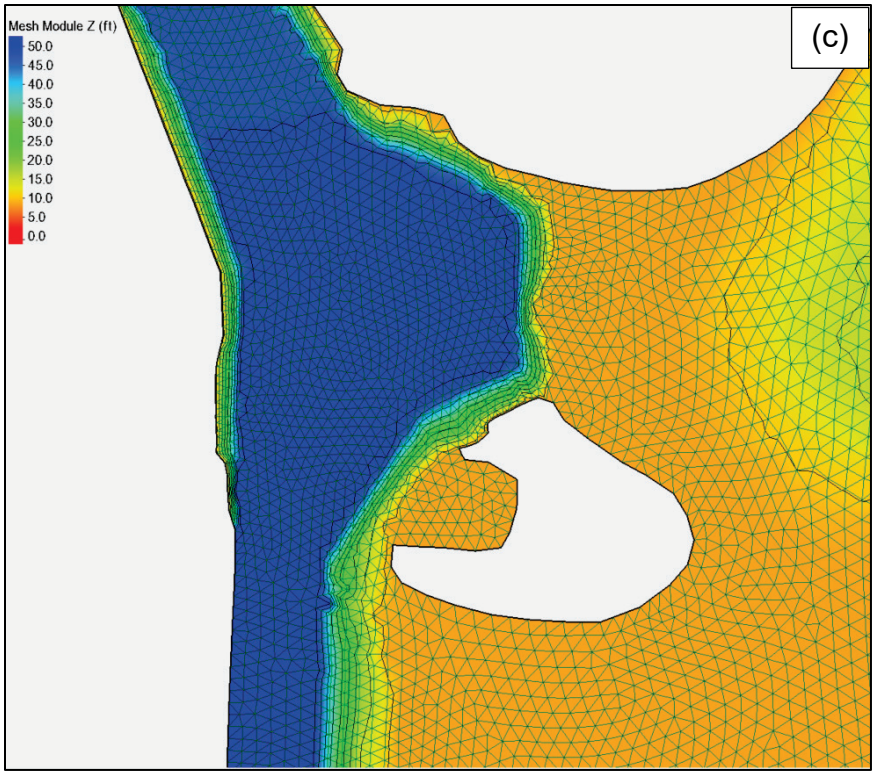


Figure 14 (cont.). Mesh around the turning basin and Little Sand Island for the three project conditions: (*a*) Project No. 1, (*b*) Project No. 2, and (*c*) Project No. 3.



3.3 Model Configuration for Existing and Project Conditions

The astronomical tides in the ADCIRC model are forced by eight dominant tidal constituents: M2, S2, N2, N1, O1, Q1, P1, and K2. A diurnal tide is dominant in the Mobile Bay. Combinations of a constant wind speed of 20 kn (10.2 m/s), wind directions of north, east, and southeast (Table 4) with low flow (LQ) conditions of 5,660 ft^3/s and high flow (HQ) of 68,000 ft^3/s (Table 5) in the Mobile River, were specified for both the existing and project conditions. Table 5 also includes the flow rates assigned to the Middle River. The HQ conditions are typical values for the Mobile River and Middle River. Both the maximum spring-tide flood and ebb-tide conditions are archived to provide flow for ship simulation. A list of ship-simulation hydrodynamic conditions is provided in Table 6.

The other important model parameters of ADCIRC are the primitive weighting parameter for the continuity equation (τ_0), lateral eddy viscosity, and Manning bottom-friction coefficient (n). For stable simulations, the values of (τ_0) are set to 0.03 on the shallow-water areas including the entire water area of Mobile Bay and the Mississippi Sound, and to 0.005 on the deep water of the Gulf of Mexico and the Atlantic

Ocean. The Manning's n is 0.02 s/m$^{1/3}$ for all the water areas of the grid. The lateral eddy viscosity is 4.0 m^2/s.

Each simulation was performed for a 20-day computational period with a time-step of 0.5 s and a 1-day ramp period. The simulations were run on a Cray High Performance Computer with 88 processors. It took approximately 2.5 hr to complete one 20-day tidal flow simulation by ADCIRC.

Table 4. Wind conditions.

Wind Direction	Wind Speed
No Wind	0 kn
N[1]	20 kn
E[2]	20 kn
SE[3]	20 kn

[1] North
[2] East
[3] Southeast

Table 5. River-flow conditions.

Flow Conditions	Mobile River (ft^3/s)	Middle River (ft^3/s)
LQ	5,660	6,500
HQ	68,000	130,000

Table 6. Archived hydrodynamic conditions for ship simulation.

—	LQ	HQ
N	—	X
E	X	X
SE	X	—

3.4 Simulation Results for Existing and Project Conditions

Hourly output of currents and water levels from each ADCIRC model simulation run is archived over the global domain. From the archived global variables, the local values at the corresponding nodes in the ship-simulation domains were extracted, and the currents for the maximum ebb and the maximum flood conditions were generated in ship-simulation format.

Under each hydrodynamic condition (Table 6), there were four simulations performed for the four project conditions (Table 3), modeled by four ADCIRC grids. As a result, a total of 16 tidal flow simulations were completed. However, only four flow states were utilized for the ship simulation: (1) maximum ebb flows with HQ river flow and east wind, (2) maximum ebb flows with HQ and north wind, (3) maximum flood flows with LQ river flow and east wind, and (4) maximum flood flows with LQ and southeast wind (Table 6). These four tidal flows are presented in Figure 15–Figure 34 and described below.

Figure 15 and Figure 16 show the maximum ebb flows generated for existing conditions from northerly wind with HQ and east wind with HQ, respectively. Both the ebb currents flow from the Mobile River upstream, through the Choctaw Pass Turning Basin, to the south of the bay. The ebb currents slow down in the turning basin due to flow diversion to the ship channel and the Choctaw Pass Turning Basin. The flows speed up again when passing through the channel by the Little Sand Island, and the main ebb currents follow the bay channel down to the south of the bay. In general, the ebb-current patterns remain similar, which flow from the river upstream to the south of the bay, slightly varying with wind conditions. Velocity magnitudes increase with increased river flows. Figure 17–Figure 22 shows similar forcing conditions of the maximum ebb flows for the three project conditions (Table 3). The responses to varying river flows are similar to those in the existing conditions. However, currents are reduced on the downstream side of the turning basin, compared to existing conditions. The reduction in current speed is mainly due to the extension and deepening of the turning basin.

Close-up views on the maximum ebb currents around the turning basin driven by the northerly wind and high river flows are shown in Figure 23 for the four simulation conditions (i.e., the existing condition, Project No.1, Project No. 2, and Project No. 3). The extension of the Choctaw Pass Turning Basin in the three project conditions (Figure 23*b*, *c*, and *d*) reduces the maximum ebb flow speeds in the turning basin and the ship channel, in comparison to those in the existing condition channel (Figure 23*a*). The maximum ebb currents in the ship channel by the McDuffie Coal Terminal also slow down slightly due to the McDuffie Coal Terminal widening (Figure 23*b*, *c*, and *d*). As shown in Figure 24, the magnitudes and directions of ebb currents under east wind are similar to the flows produced by the north wind and HQ.

The maximum flood flows are identified as the flow field when the tide rises to the highest tide level during the 20-day simulation period. For the results of the maximum flood flows, Figure 25–Figure 32 depict the flow fields over a large water area from the Mobile River (with a low flow rate) to the navigation channel at the south of the Coal Terminal for the four simulation conditions (Table 3), respectively. Flow directions of the maximum flood currents under the low river flow are from the south to the north, which means the flood tide under this situation can flood up to the Mobile River.

Close-up views of the maximum flood flows for the four hydrodynamic conditions (Table 6) are plotted in Figure 33 and Figure 34 for comparisons of the flood flows by the four simulation conditions (Table 3) under the low river flow condition. Both the east and southeast wind show some reduction in the maximum flood currents in the channel at the south of the turning basin. However, the extension and terminal widening may reduce more flood currents under the east wind in the area of the harbor.

Figure 15. Simulated maximum ebb flows (knots) with north wind and high flow (HQ) for existing conditions.

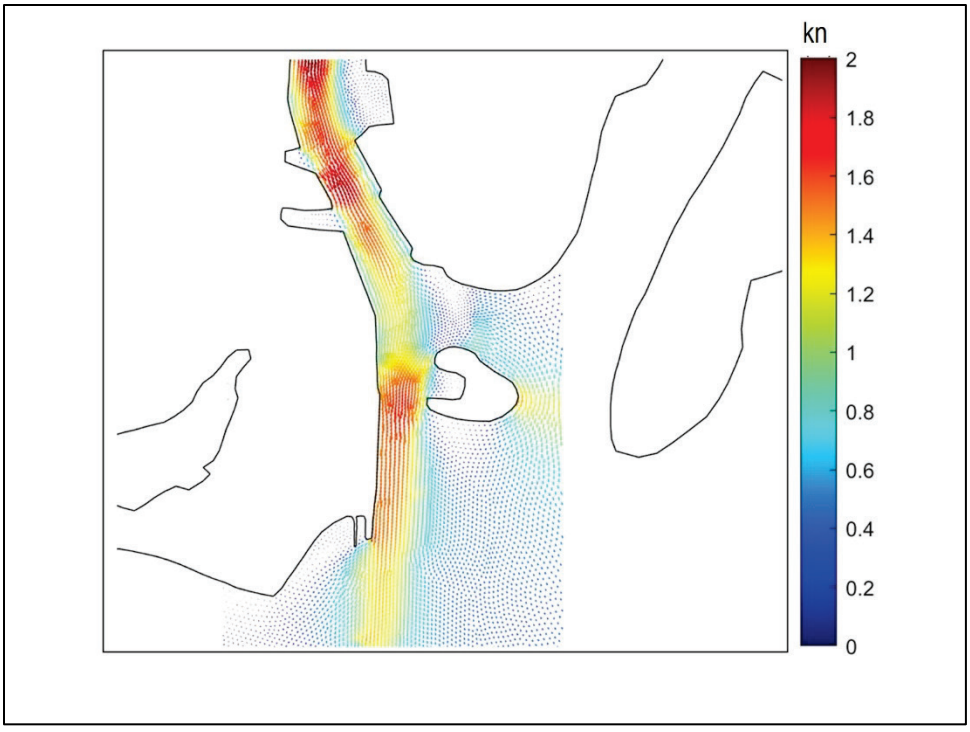


Figure 16. Simulated maximum ebb flows (knots) with east wind and HQ for existing conditions.

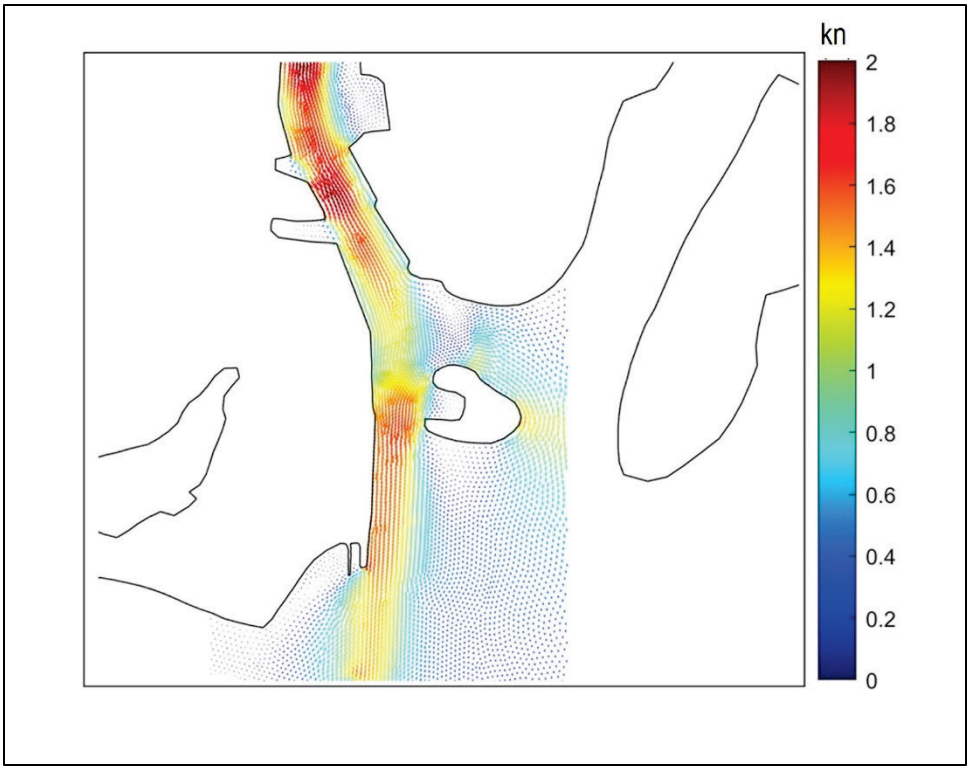


Figure 17. Simulated maximum ebb flows (knots) with north wind and HQ for Project No. 1.

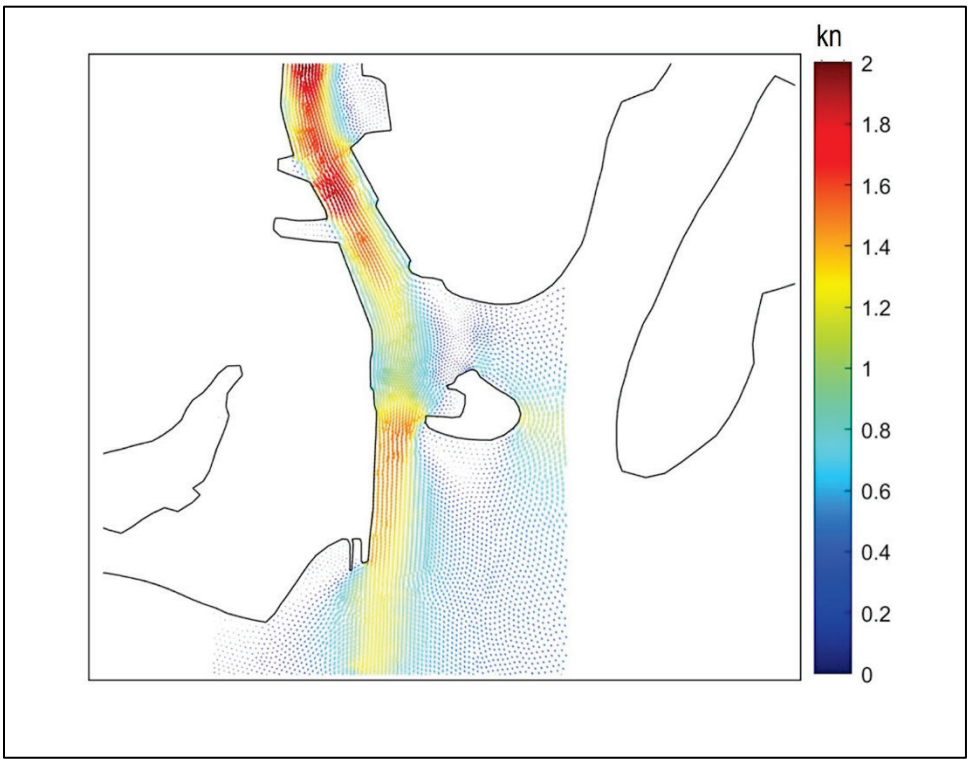


Figure 18. Simulated maximum ebb flows (knots) with east wind and HQ for Project No. 1.

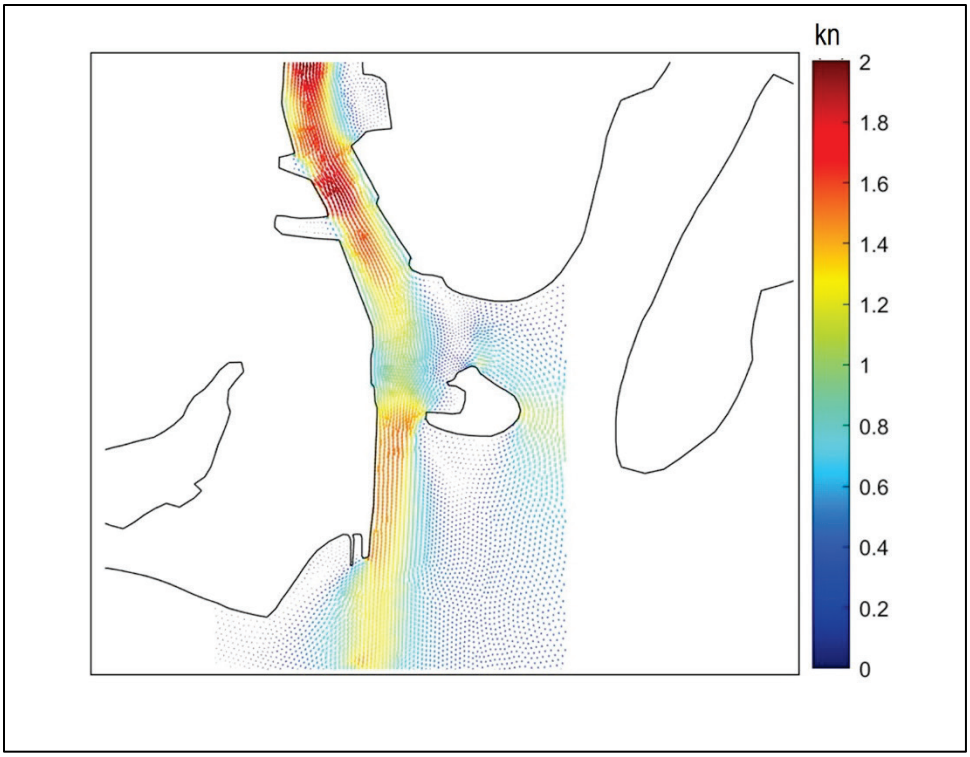


Figure 19. Simulated maximum ebb flows (knots) with north wind and HQ for Project No. 2.

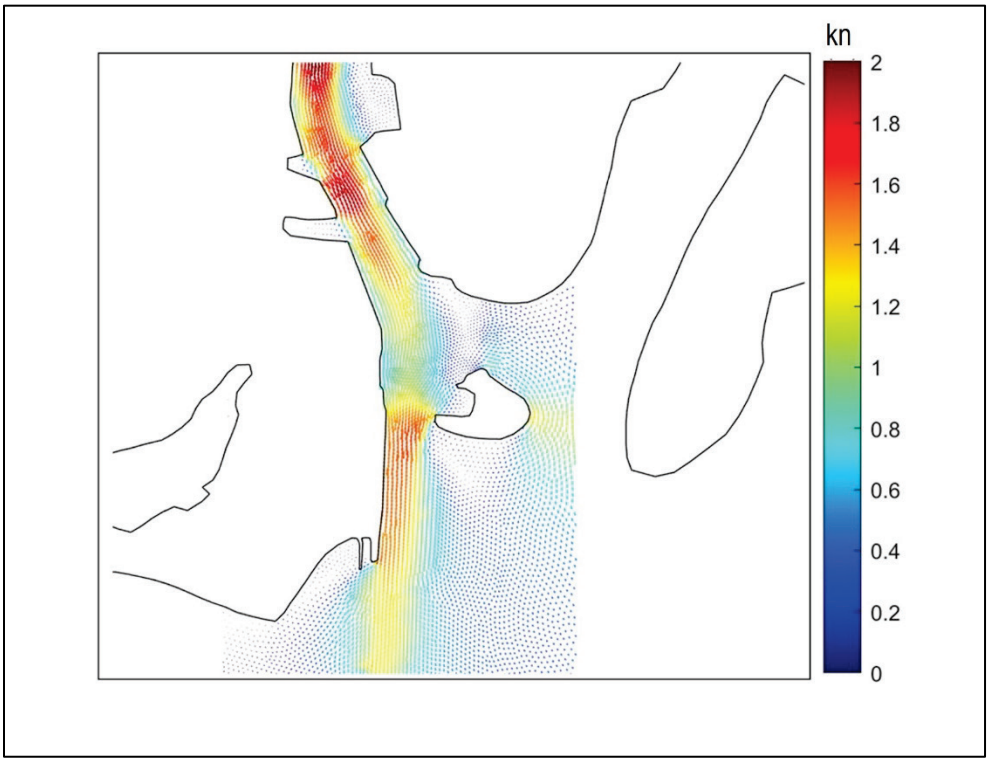


Figure 20. Simulated maximum ebb flows (knots) with east wind and HQ for Project No. 2.

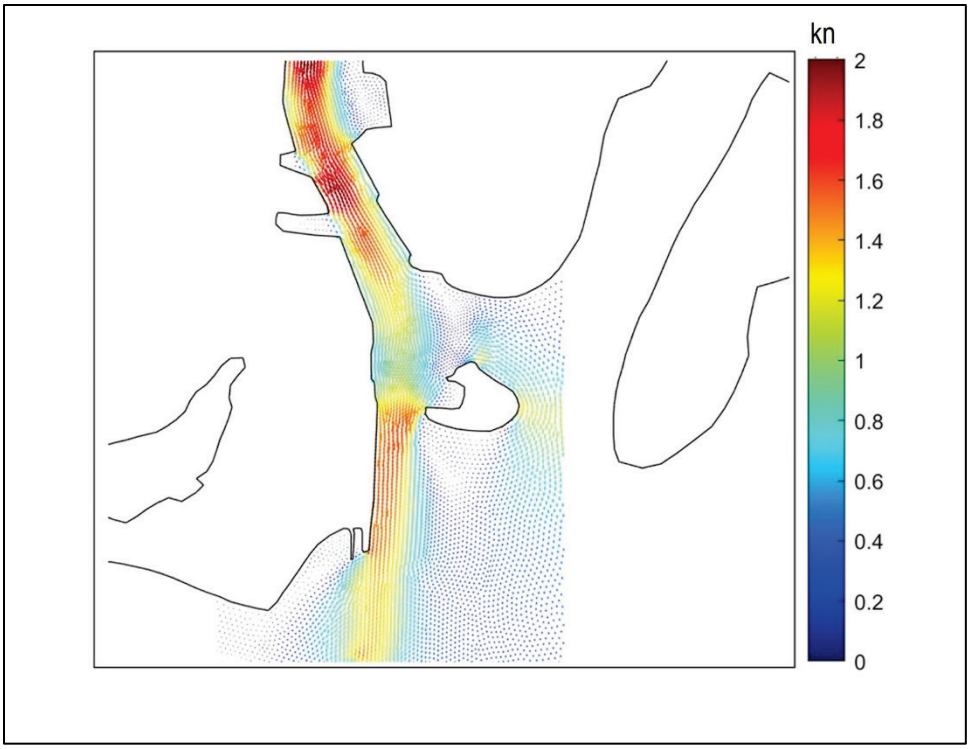


Figure 21. Simulated maximum ebb flows (knots) with north wind and HQ for Project No. 3.

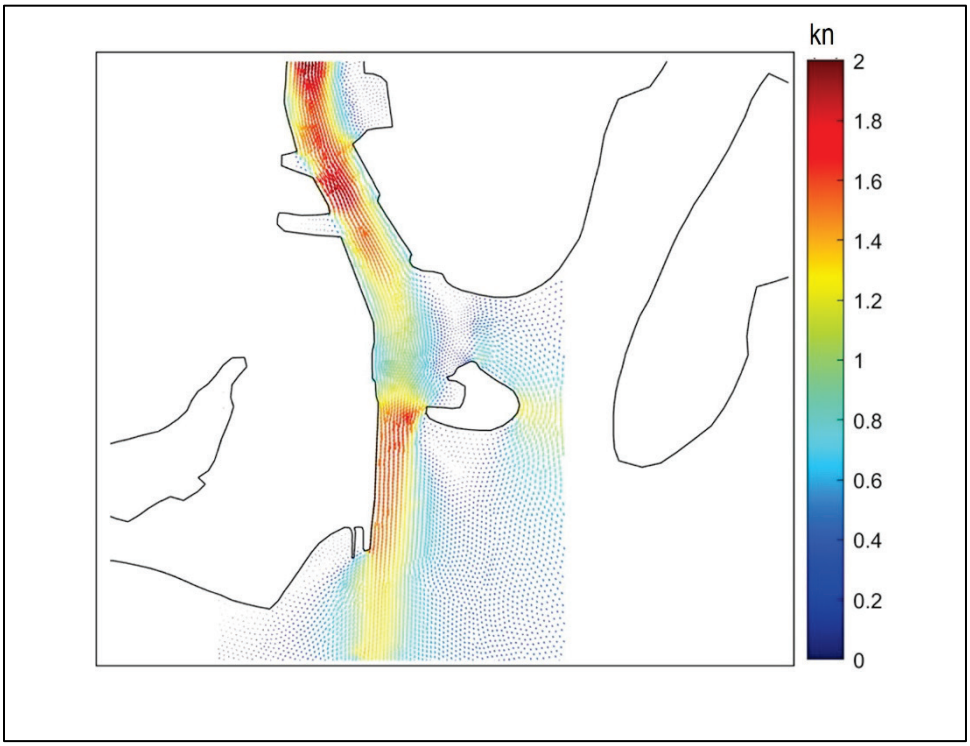


Figure 22. Simulated maximum ebb flows (knots) with east wind and HQ for Project No. 3.

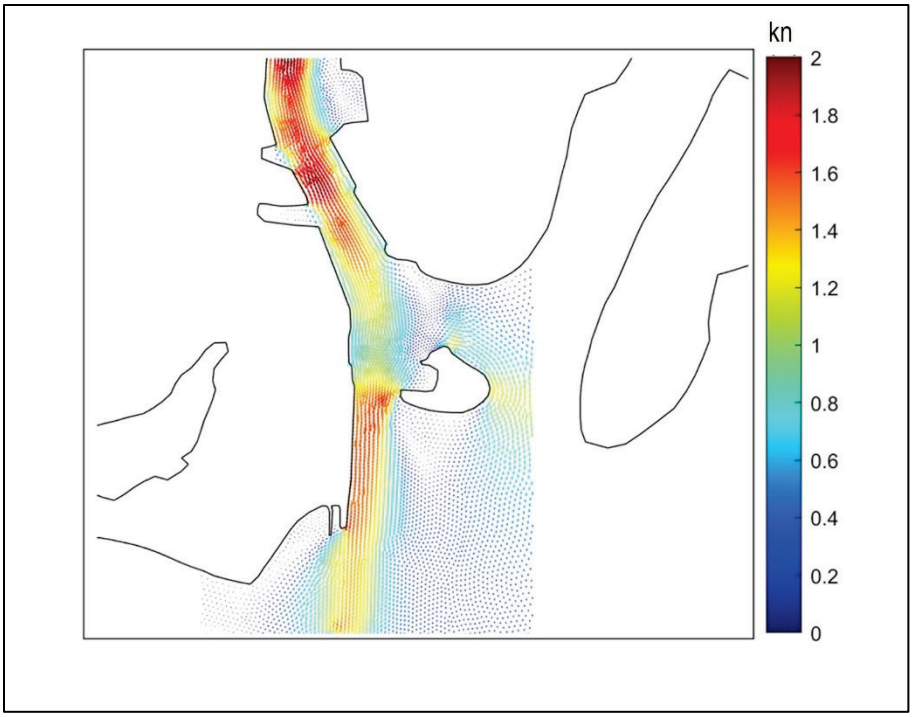


Figure 23. Comparisons of maximum ebb flow (knots) with north wind and HQ for existing and project conditions.

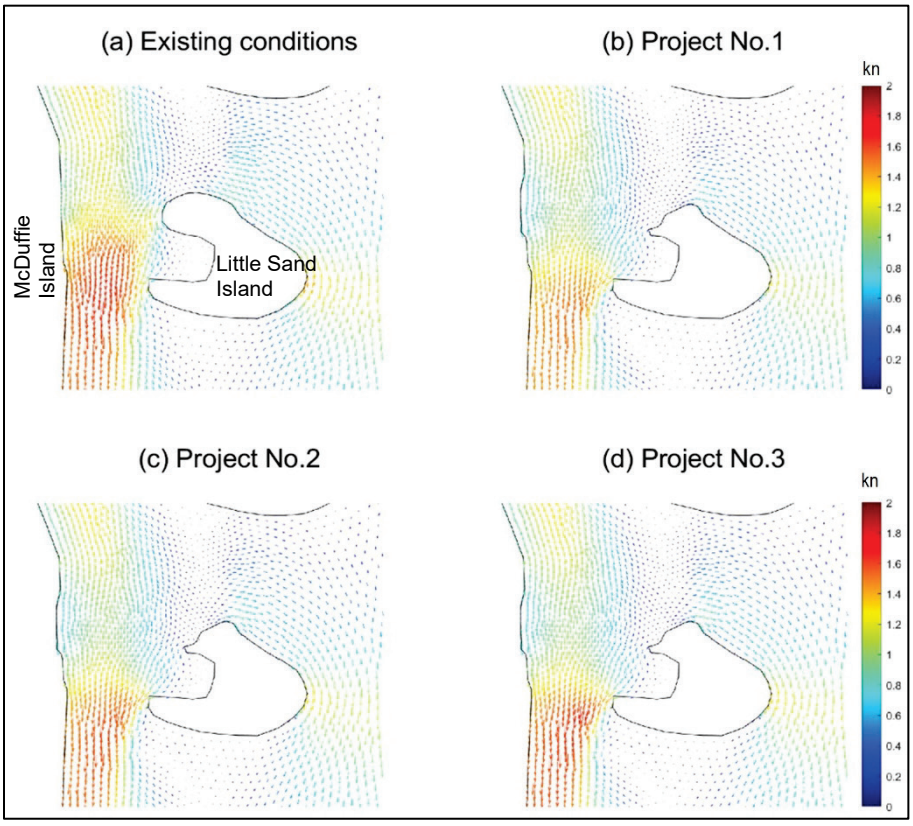


Figure 24. Comparisons of maximum ebb flow (knots) with east wind and HQ for the existing and project conditions.

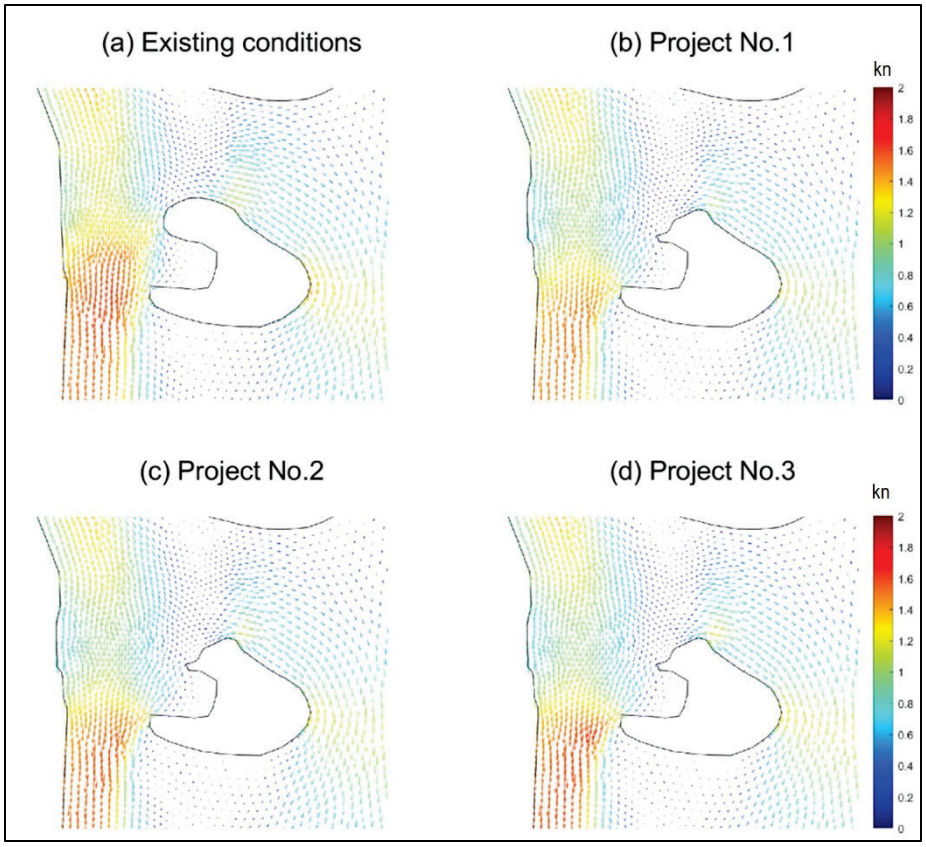


Figure 25. Simulated maximum flood flows (knots) with east wind and low flow (LQ) for existing conditions.

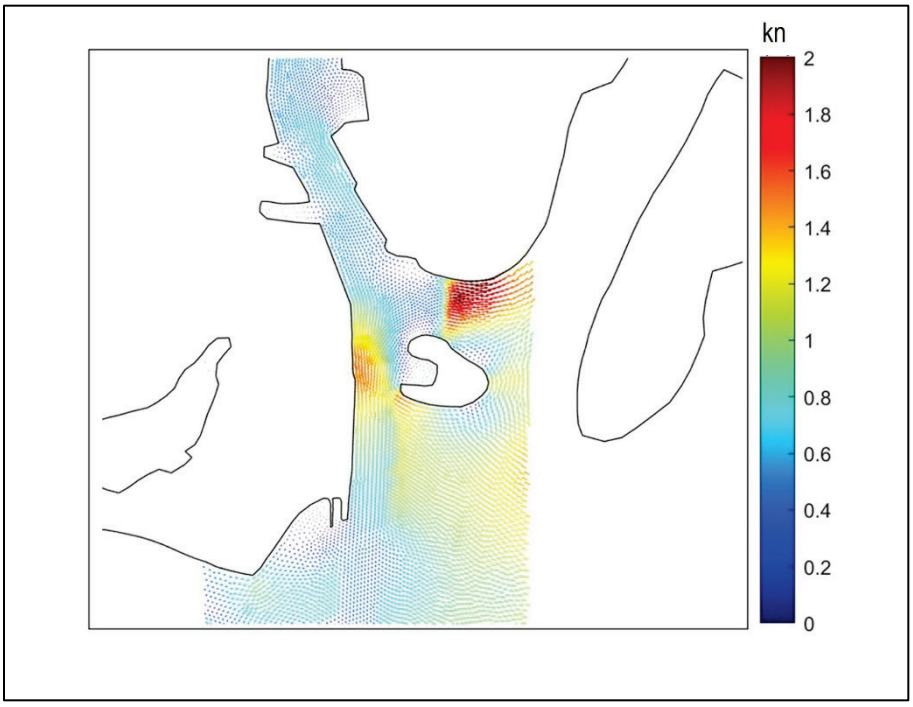


Figure 26. Simulated maximum flood flows (knots) with southeast wind and LQ for existing conditions.

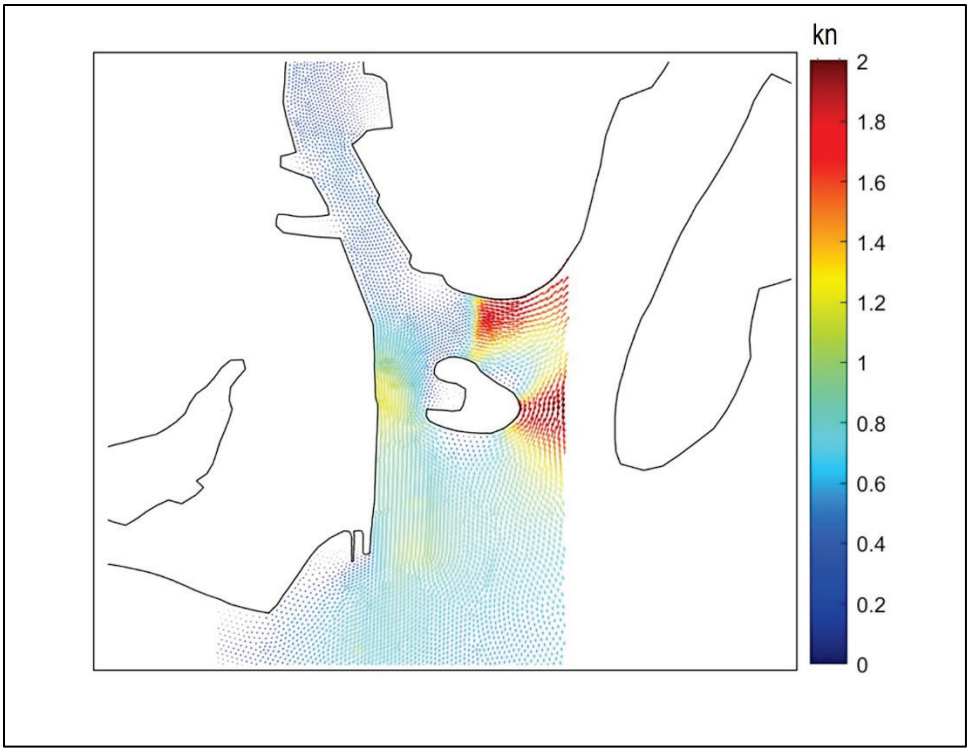


Figure 27. Simulated maximum flood flows (knots) with east wind and LQ for Project No. 1.

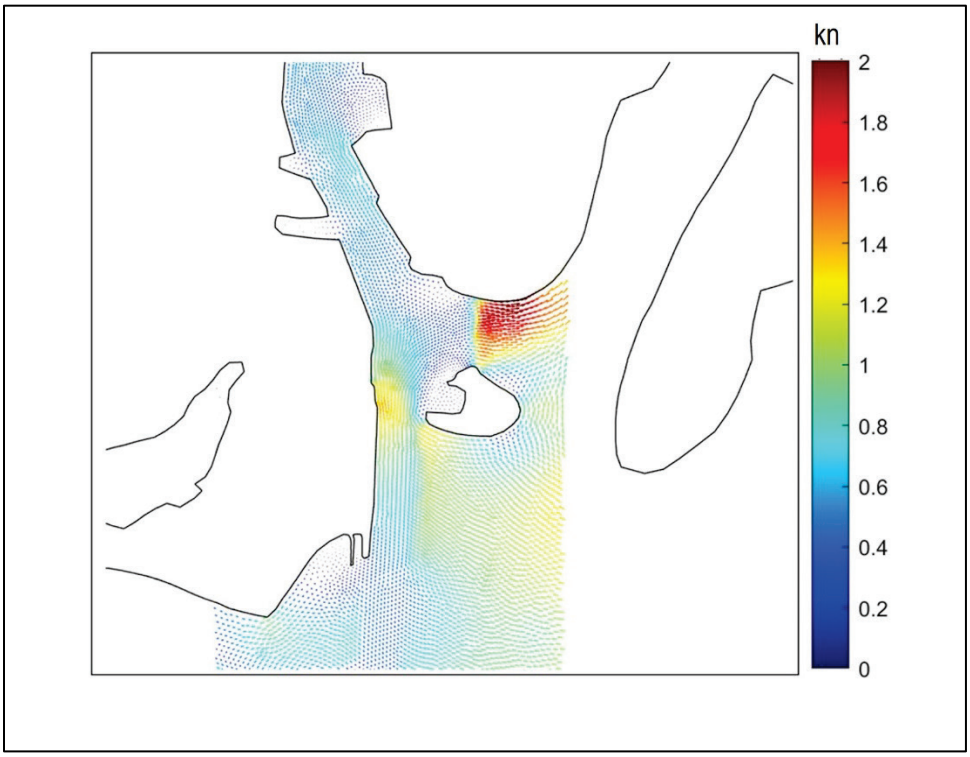


Figure 28. Simulated maximum flood flows (knots) with southeast wind and LQ for Project No. 1.

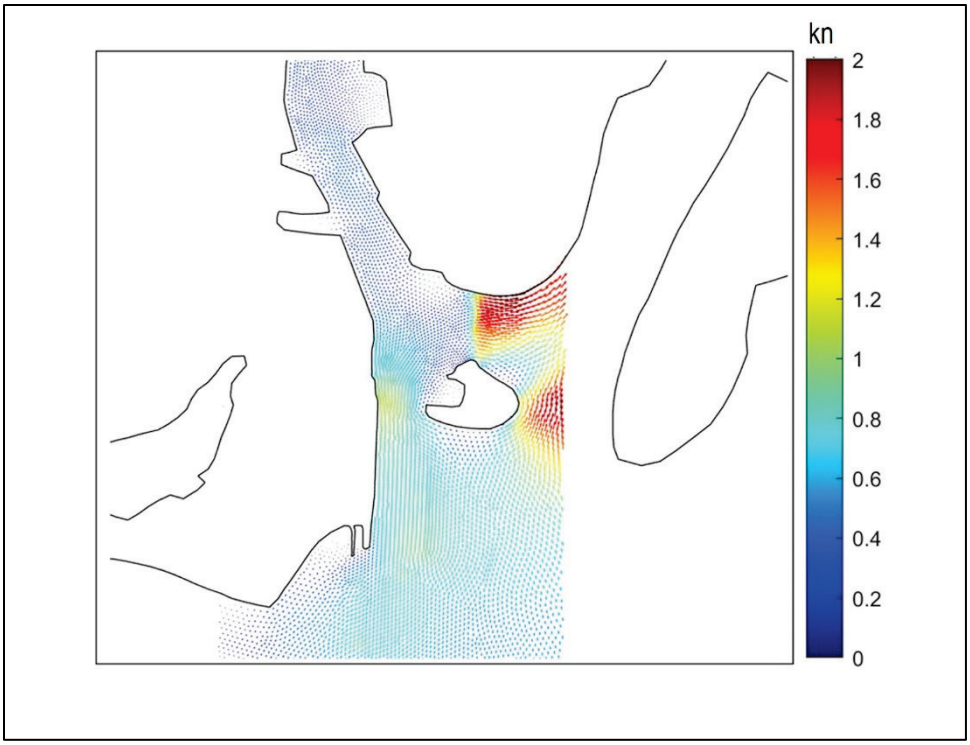


Figure 29. Simulated maximum flood flows (knots) with east wind and LQ for Project No. 2.

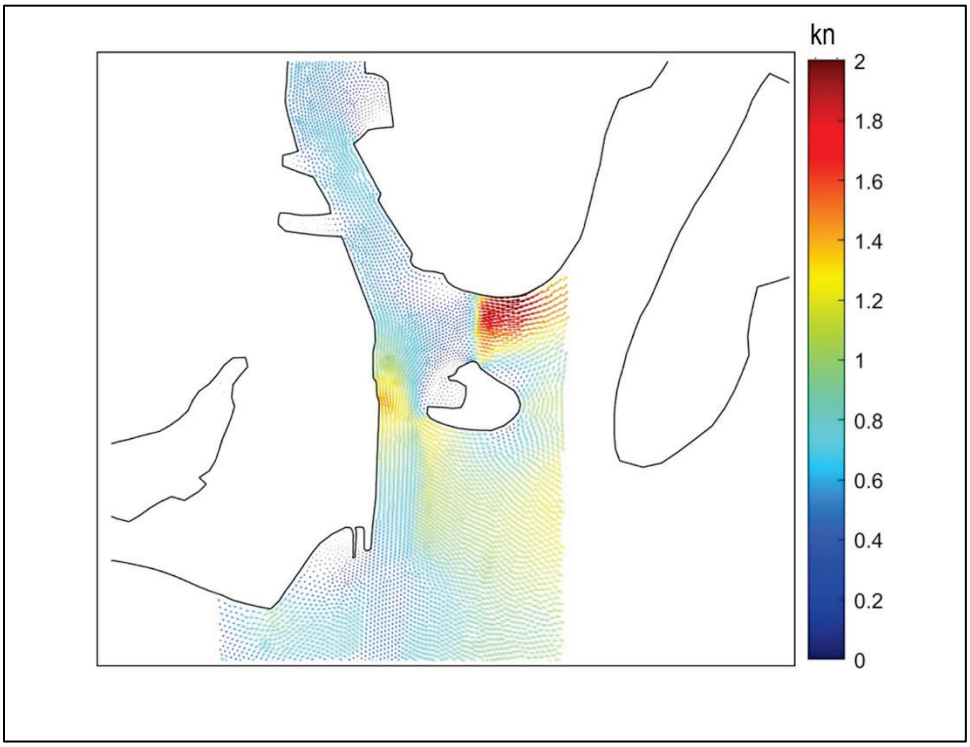


Figure 30. Simulated maximum flood flows (knots) with southeast wind and LQ for Project No. 2.

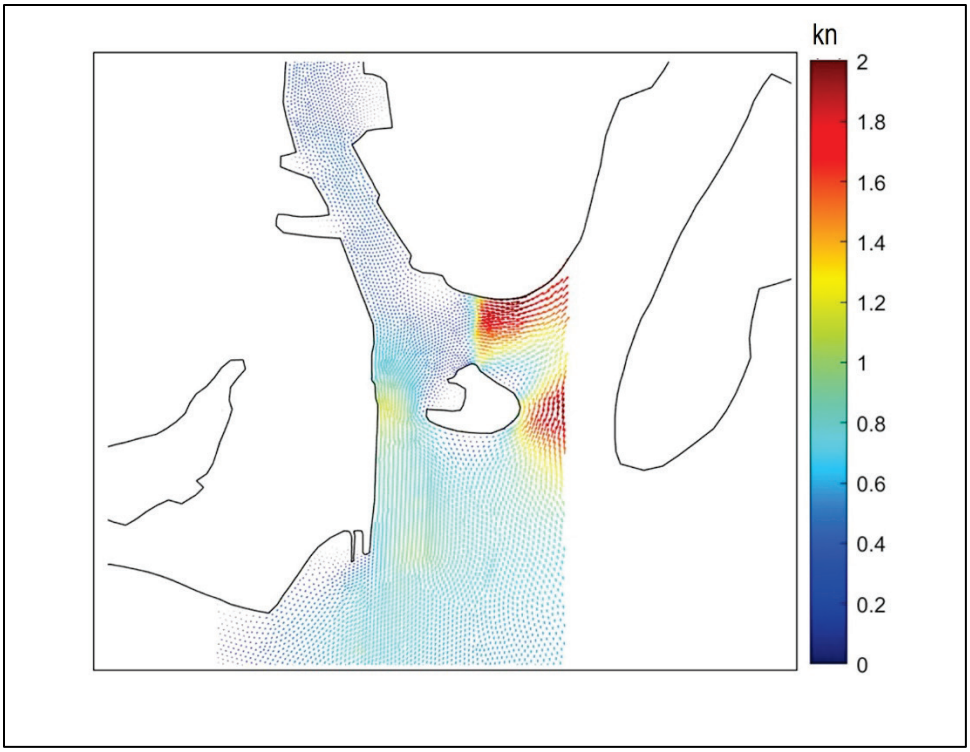


Figure 31. Simulated maximum flood flows (knots) with east wind and LQ for Project No. 3.

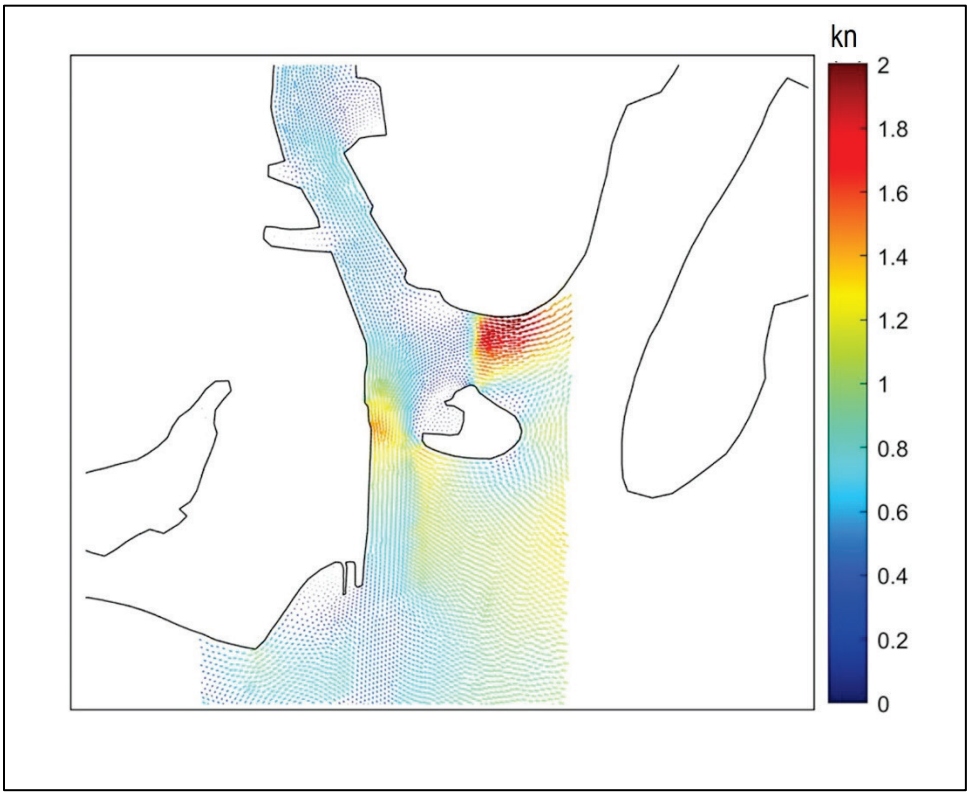


Figure 32. Simulated maximum flood flows (knots) with southeast wind and LQ for Project No. 3.

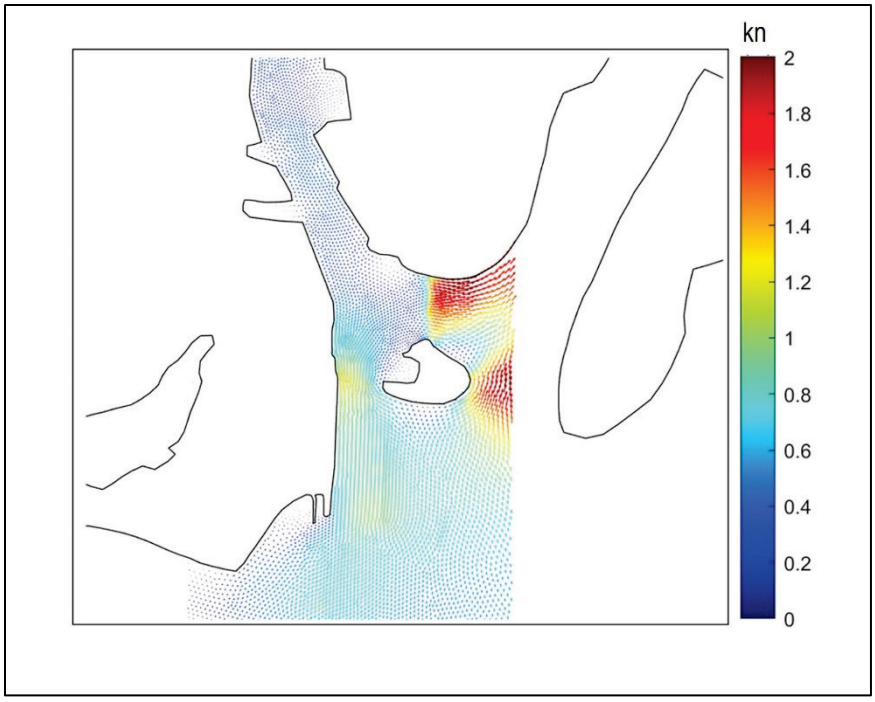


Figure 33. Comparisons of maximum flood flows (knots) with east wind and LQ for the existing and project conditions.

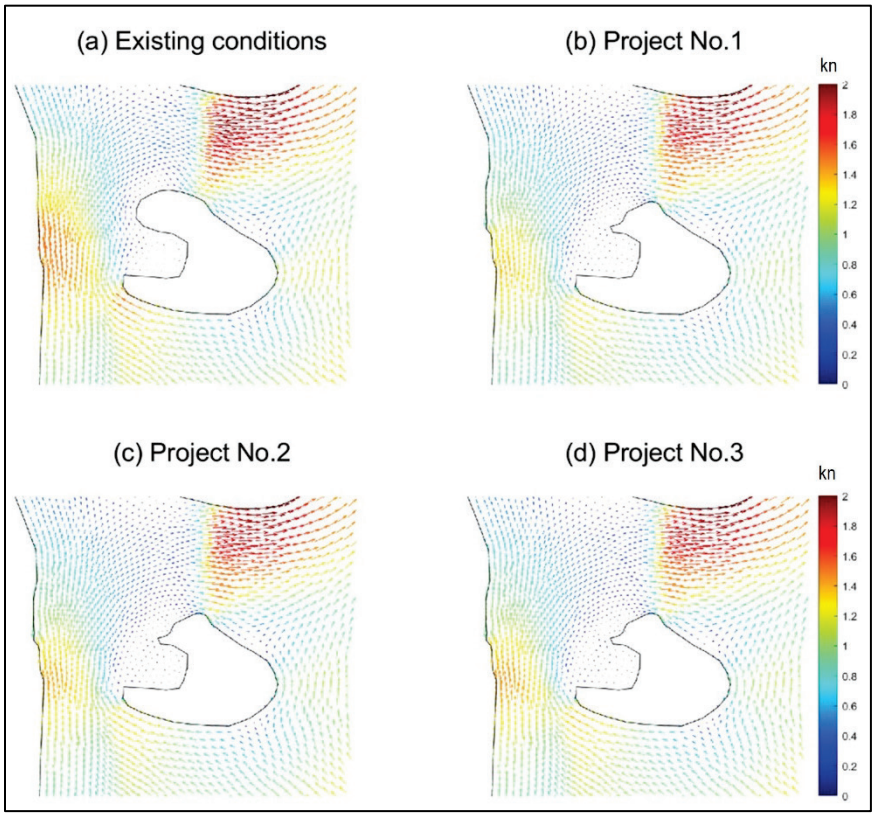
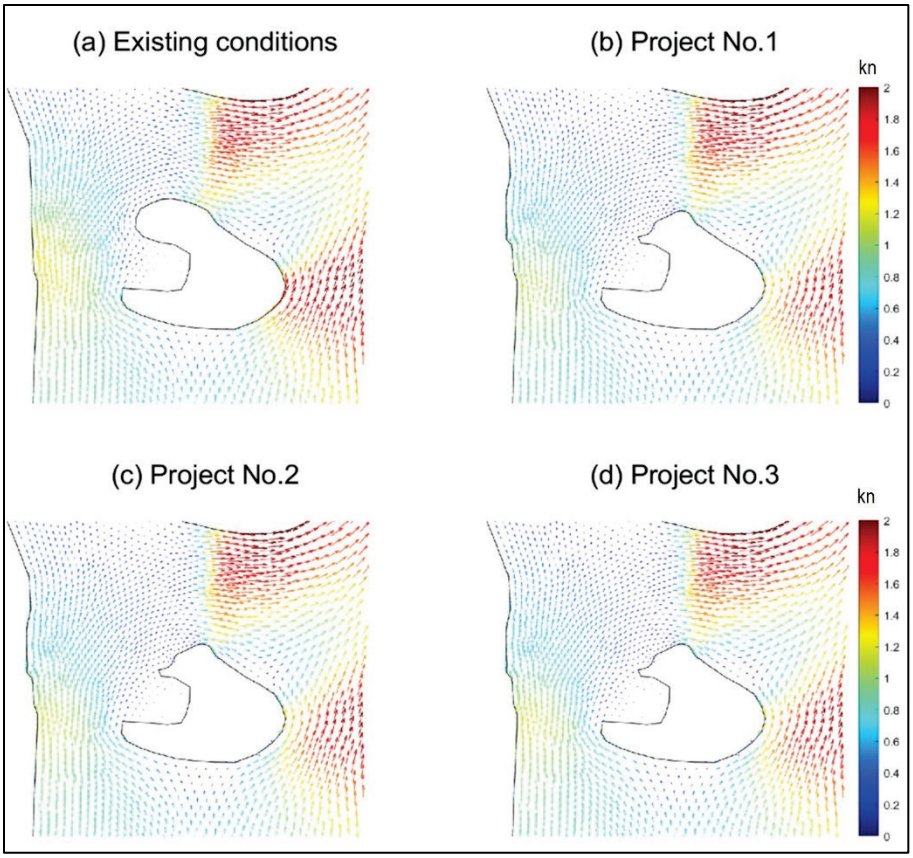


Figure 34. Comparisons of maximum flood flows (knots) with southeast wind and LQ for the existing and project conditions.



3.5 Remarks

By using the ADCIRC model, tidal flow simulations were performed on refined triangular grids. The tidal flows under the existing conditions and three project conditions around the Mobile Harbor with different river flow rates and wind conditions were successfully simulated by using the four high-resolution ADCIRC grids.

Simulation results about the maximum flood and maximum ebb currents were extracted from the ADCIRC results over a 20-day long tidal simulation period. Those maximum flow fields for the simulation conditions and under four hydrodynamic forces (Table 6) were generated in a format suitable for input into the ERDC STS.

Analysis of the maximum-flow fields (for ebb and flood) shows that the project conditions (i.e., the extension of the Choctaw Pass Turning Basin and the McDuffie Coal Terminal widening as given in Table 3) can reduce the maximum velocities of ebb and flood currents around the harbor area and the navigation channel by the McDuffie Coal Terminal.

4 Database Development

During a ship simulation, there are a variety of environmental forces that act upon vessels during a transit. Some of these forces include wind, waves, currents, bathymetry, and ship-to-ship interaction. Virtual databases are developed as input into the ERDC STS for the area of interest for existing conditions first. The existing-conditions databases are validated with experienced mariners and then modified to replicate proposed future conditions. Testing of the proposed future conditions are referred to as *production runs*.

4.1 Design Vessel

Table 7 lists the vessels that were used in this study. CNTNR49 was selected as the design vessel, and it was used as the transiting vessel for all the simulations conducted.

Table 7. Vessels used in testing.

Vessel Name	Vessel Model	Vessel Type	Length (ft)	Width (ft)	Draft (ft)	Purpose in Study
Maersk Guayaquil	CNTNR49[1]	Containership	1,105.6	158.5	47.0	Design vessel; transiting vessel for all simulations
Regina Oldendorff	BULKC19[2]	Bulk coal carrier	853.0	141.2	47.0	Moored vessel at McDuffie Coal Terminal
Orion Voyager	VLCC13P[3]	Crude oil tanker	900.0	164.0	48.0	Moored vessel at McDuffie Coal Terminal

[1] CNTNR = Containership
[2] BULKC = Bulk carrier
[3] VLCC = Very large crude carrier

Additional information, in the form of pilot cards, can be found in Appendix C for the design vessel and docked vessels (see Section 4.4, Mooring Information). Pilot cards are provided to pilots prior to beginning ship simulations so that they can become familiar with vessel particulars before maneuvering.

4.2 Visual Database

The visual database created for the 2020 study was used for this study. No major visual additions were requested by the pilots for incorporation in this visual scene. The database extends from the entrance channel to just north of the Choctaw Pass Turning Basin. Additionally, a radar and Electronic Chart Display and Information System files were created for each alternative.

4.3 Environmental Database

An environmental database was created for Mobile Bay that included current, bathymetric, and wind data. Bathymetric survey data from late 2016 was incorporated into the ERDC STS and the numerical model. Proposed channel lines were provided by CESAM along with channel slope, which were used to modify the survey data to create the proposed-condition databases.

4.3.1 Wind

Wind was incorporated in the creation of the currents to capture wind-driven current effects. Wind was also added in the simulator to capture above-water wind effects. A total of four environmental conditions were tested in this study (Table 8).

4.3.2 Currents

Currents for the study were developed using the ADCIRC model. Table 9 lists the channel alternatives and the currents that were paired with them. Note the current naming convention (Project No. 1, Project No. 2, Project No. 3) (Table 3) is different than the ship simulator naming convention (P3, P2A, P75, P3A). No simulations were completed for the +50 ft original alternative (P2) or either +150 ft alternatives (P4 and P4A). Validation took longer than expected during the first set of simulations, so the time available to complete production run testing was extremely limited. Due to this schedule constraint, P3 was prioritized for testing since it was the alternative that existed in between the other alternatives (Figure 6). Selecting a middle alternative would provide insight into if one of the alternatives could be removed for the second round of testing. Following feedback from the testing of the P3 alternative, the channel alternatives were modified (P2A, P3A, P4A, and P75) to extend the expansion farther south and create a more gradual transition (Figure 8). The P4A alternative

was not tested as the pilots were largely successful (see Section 7) in the P3A channel, and the pilots endorsed P3A as being adequate. Therefore, it was determined it was not necessary to perform ship simulations with the larger proposed channel.

Table 8 lists the various currents that were utilized in the ERDC STS for each testing area. Ebb conditions were paired with high river flows (Mobile and Middle River) while flood conditions were paired with low river flows to attain maximum navigable environmental conditions. Maximum navigable environmental conditions are considered the most extreme environmental conditions at which a pilot would continue to navigate the design vessel. If navigation would cease, it is not useful to test those conditions in the ship simulator. Further description of the current development can be found in Section 3, Hydrodynamic Modeling for the Ship Simulator, section of this report.

Table 8. Currents used in each testing area.

Mobile and Middle River Flow Condition	Tide	Wind Speed	Wind Direction
HQ	Ebb	20 kn	N
HQ	Ebb	20 kn	E
LQ	Flood	20 kn	E
LQ	Flood	20 kn	SE

Table 9. Channel alternatives description and paired currents.

Alternative	Channel Alternative Description	Currents
P0	Existing channel	Existing Condition
P2	+50 ft, original transition *(not tested in simulator)*	Project No. 3
P3	+100 ft, original transition	Project No. 2
P4	+150 ft, original transition (not tested in simulator)	Project No. 1

Table 9 (cont.). Channel alternatives description and paired currents.

Alternative	Channel Alternative Description	Currents
P2A	+50 ft, modified transition	Project No. 3
P75	Modified +75 ft, modified transition	Project No. 3
P3A	+100 ft, modified transition	Project No. 2
P4A	+150 ft, modified transition (not tested in simulator)	Project No. 1

4.3.3 Visibility

While various visibility conditions were tested during the 2020 study (foggy and nighttime), only clear daytime simulations were tested in this surge-analysis study. During the 2020 study, pilots stated that in Mobile Harbor they would not attempt to turn larger vessels during foggy conditions and that tugboats likely would not operate during foggy conditions. While the pilots would bring in a vessel this size (1,105.6 × 158.5 × 47.0 ft) during nighttime, pilots expressed that they did not believe that nighttime runs were significantly more difficult than daylight runs. The 2020 study supports this assessment as turning basin nighttime simulations were rated at a 2.7 and 2.3 for run difficulty and run safety, respectively (rated from 1 to 5 with lower scores equating to safer, less-difficult transits). Daytime turning basin simulations were rated at a 3.1 and 2.2 for run difficulty and run safety, respectively. Due to the minor difficulty and safety differences and limited time, clear daytime simulations were the focus for this study.

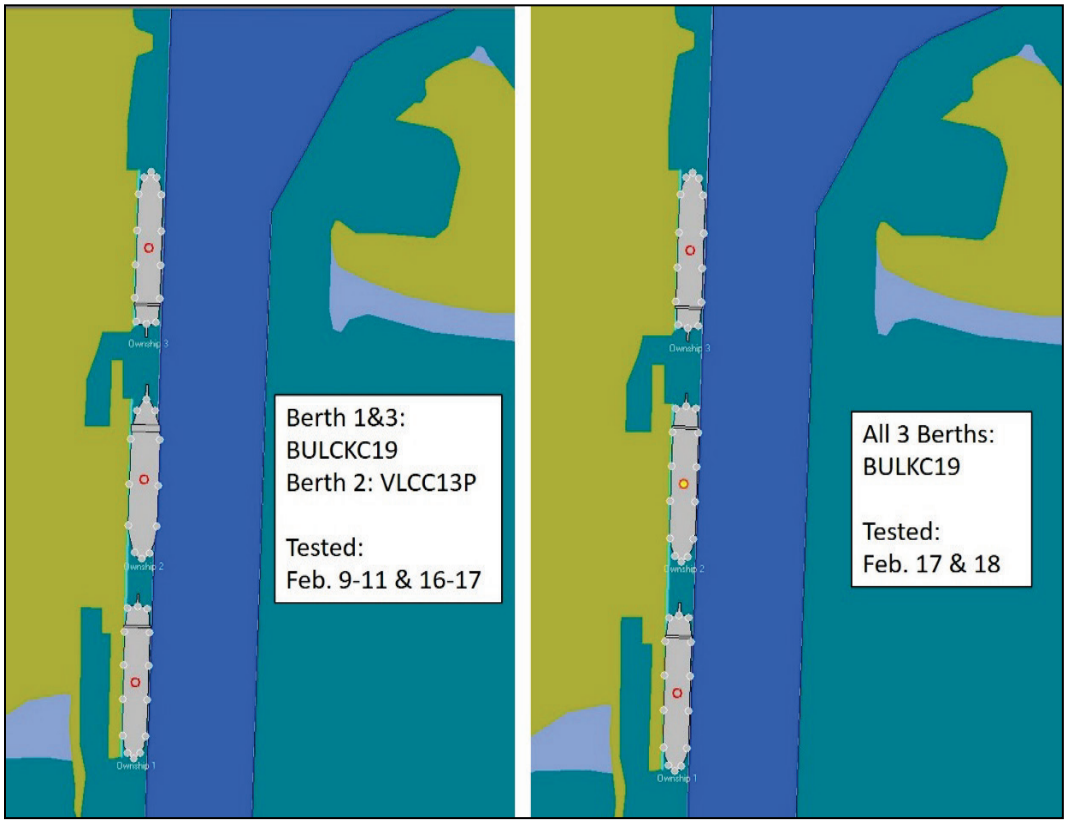
4.4 Mooring Information

Determining representative mooring information is difficult because vessel dimensions, line characteristics, and line configurations largely vary between calling vessels. A representative mooring scenario was selected for input into the ship simulator; however, not all mooring variations are encompassed by this selection.

Mooring representation was determined based on information collected from the Mobile Bar Pilots, Alabama Port Authority Facilities Engineer, Harbormaster, and the McDuffie Coal Terminal General Manager. Based on vessels currently docking at the McDuffie Coal Terminal, two vessels

were selected to represent the docked vessels for the proposed conditions: BULKC19 and VLCC13P (see Table 7 for dimensions and 0 for pilot cards). These two vessels were selected as they have similar length and width dimensions of the current docked vessels but have a deeper draft. Pilots use the term *head up* to describe docked vessels with the bow facing north and *head down* for bow facing south. The BULKC19 was selected to be berthed at the McDuffie Coal Terminal #1 (head down) and #3 (head up). The VLCC13P was selected to be berthed at McDuffie Coal Terminal Dock #2 (head down). However, during simulation testing, it was noticed that minimal surge and sway was being recorded for the VLCC13P in scenarios where movement was expected to occur. Because of this lack of movement, it was determined to represent all three docked vessels as the BULKC19 (Figure 35) in simulations going forward starting on 17 February 2022. The vessel model manufacturer confirmed after simulations were completed that the surge and sway calculations for the VLCC13P were from an outdated formulation that was causing the reduced movement calculations.

Figure 35. Various moored-vessel configurations tested.



Mobile Bar Pilots provided approximate latitudes and longitudes for the various land bollards available for the McDuffie Coal Terminals. McDuffie Coal Terminal drawings were also provided, which specified heights of the fenders. These fender heights were matched in the simulator.

Typical mooring configuration is 4-2-2 (head or stern-breast-spring). McDuffie Coal Terminal #1 typically does not use aft breast lines but instead uses additional stern lines. Mooring-line characteristics (breaking strength, length, mass, and elasticity) were selected based on mooring lines used for the *AOM Elena* bulk carrier (836 ft long × 141 ft wide), which is an average-sized vessel that calls on the Port of Mobile. The rope is made of polypropylene resin and polyester yarn. The rope has a minimum breaking load (MBL) of 114.0 tons. Pretensioning was set to 20 tons, or approximately 18% of the MBL. This value was selected based on recommendation from a ship-simulation expert who has experience performing mooring-line studies with the ship-simulator software the ERDC STS uses (Polaris). A previous technical report for a mooring study in Port Arthur, Texas, also used a similar pretensioning value (10% of the MBL) (Fenical 2015).

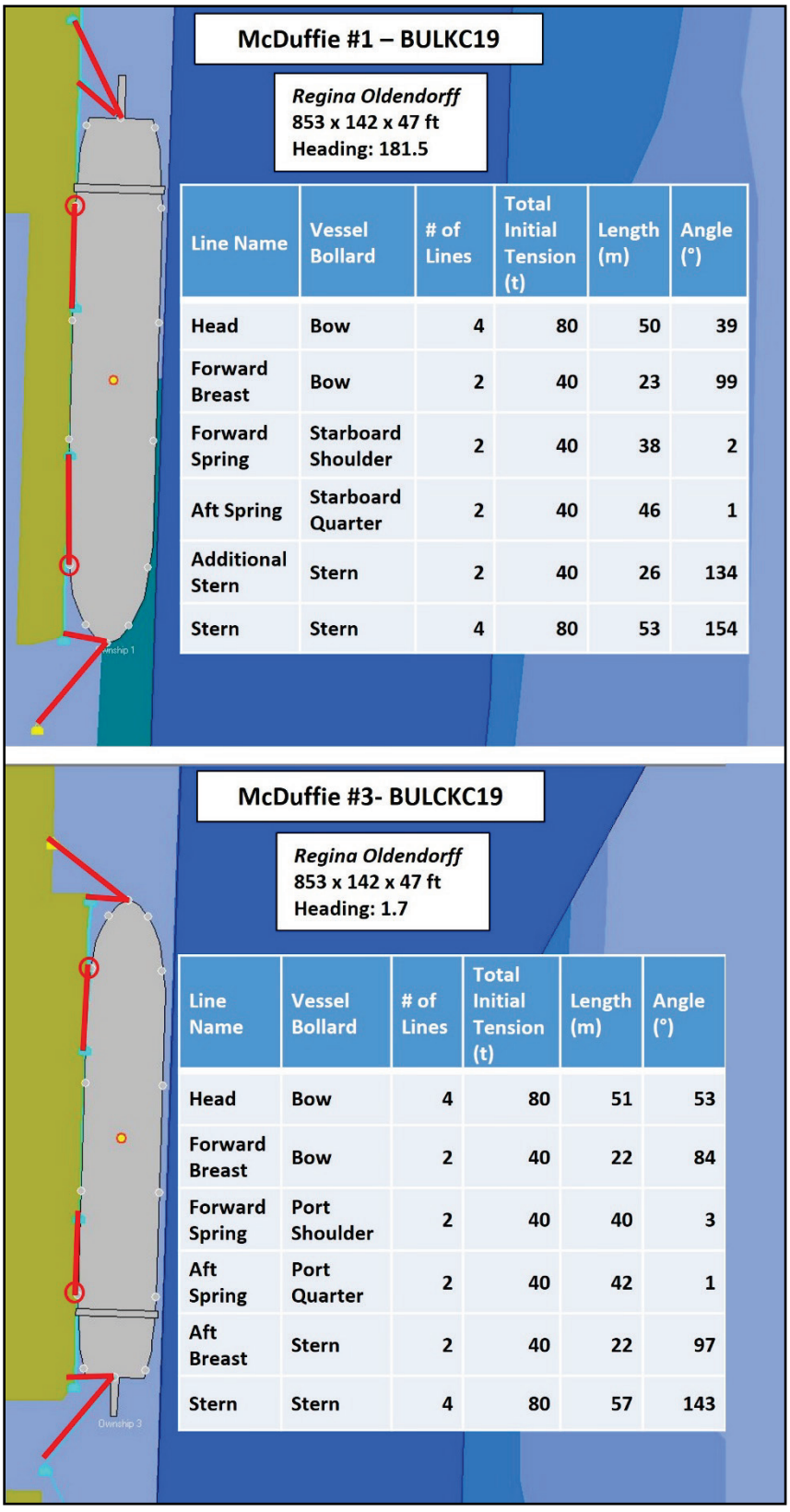
Mooring-line characteristics (i.e., mass, break force, pretension) were scaled to represent multiple lines as a single line. One line was programmed to represent two lines for breast, spring, and additional stern lines. A second line was programmed to represent four lines for head and stern lines.

During preliminary testing of procedures prior to pilot participation, it was observed that the tensioning of the mooring lines shifted dramatically once the simulation began when current was included. In past studies, ERDC personnel have observed similar unrealistic reactions when a transiting vessel is started in strong crosscurrents. When a simulation begins, the forces due to currents are introduced to the vessel all at once. In real life, the currents would slowly get stronger or weaker as the vessel transits the waterway and the pilot is able to slowly adjust ship operations to the changes; however, the simulation begins with the vessel in a single instant in time, so no previous adjustments have been made other than initial vessel conditions (speed, heading, rudder, and engine settings). To account for this, winches were added to the head, forward breast, aft breast, and stern lines of each moored vessel. The winches were set to a constant tension of 40 tons for the breast and spring lines and 80 tons for

the head and stern lines for the first minute of simulated time. After approximately 1 min of simulated time, the winches were released, and a constant line length was used instead. This allowed the moored vessels to become accommodated to the current and settle to an equilibrium prior to introducing the ship interaction. When reviewing the movement of the moored vessels, the first 2 min of the simulation were removed from analysis as the winches and current accommodation were controlling the movement. Special attention was given to ensure the transiting vessel began far enough back that it would not be close to the docked vessels when the winches were released to ensure that any vessel interaction effects were not removed.

Figure 36 shows the mooring configuration details for McDuffie Coal Terminal berths #1 and #3. Figure 37 shows the various mooring configuration details for McDuffie #2. A spreadsheet was provided at each STS operator station so that the mooring lines could be reconnected using the same procedure each time. The failure threshold for movement in surge or sway was set at 3 ft based on guidance provided by the harbormaster.

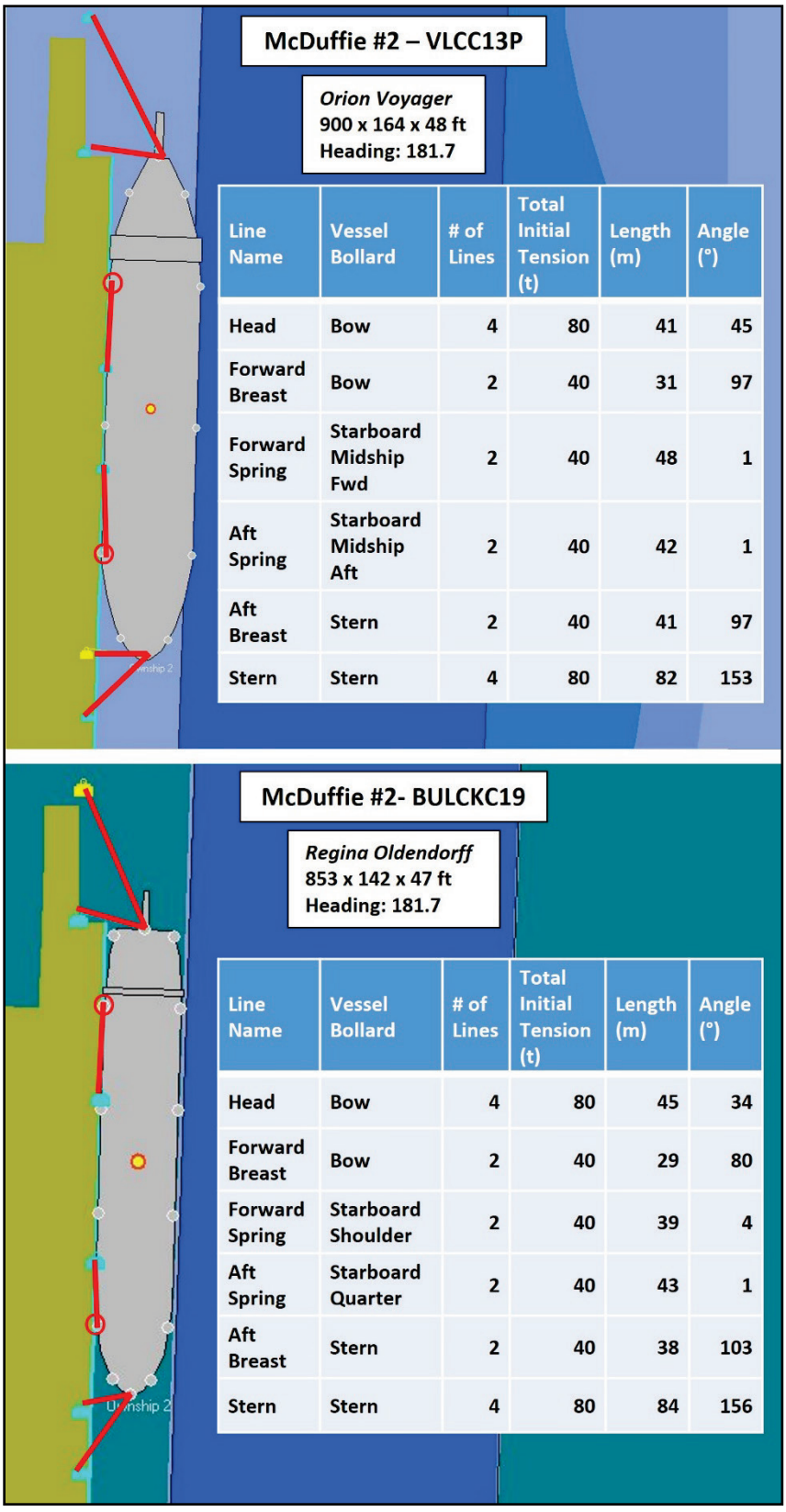
Figure 36. McDuffie #1 and McDuffie #3 mooring-configuration details.



Line Name	Vessel Bollard	# of Lines	Total Initial Tension (t)	Length (m)	Angle (°)
Head	Bow	4	80	50	39
Forward Breast	Bow	2	40	23	99
Forward Spring	Starboard Shoulder	2	40	38	2
Aft Spring	Starboard Quarter	2	40	46	1
Additional Stern	Stern	2	40	26	134
Stern	Stern	4	80	53	154

Line Name	Vessel Bollard	# of Lines	Total Initial Tension (t)	Length (m)	Angle (°)
Head	Bow	4	80	51	53
Forward Breast	Bow	2	40	22	84
Forward Spring	Port Shoulder	2	40	40	3
Aft Spring	Port Quarter	2	40	42	1
Aft Breast	Stern	2	40	22	97
Stern	Stern	4	80	57	143

Figure 37. Various McDuffie #2 mooring-configuration details.



Line Name	Vessel Bollard	# of Lines	Total Initial Tension (t)	Length (m)	Angle (°)
Head	Bow	4	80	41	45
Forward Breast	Bow	2	40	31	97
Forward Spring	Starboard Midship Fwd	2	40	48	1
Aft Spring	Starboard Midship Aft	2	40	42	1
Aft Breast	Stern	2	40	41	97
Stern	Stern	4	80	82	153

Line Name	Vessel Bollard	# of Lines	Total Initial Tension (t)	Length (m)	Angle (°)
Head	Bow	4	80	45	34
Forward Breast	Bow	2	40	29	80
Forward Spring	Starboard Shoulder	2	40	39	4
Aft Spring	Starboard Quarter	2	40	43	1
Aft Breast	Stern	2	40	38	103
Stern	Stern	4	80	84	156

5 Validation

During the validation portion of a ship-simulation study, local pilots evaluate the existing conditions database to identify any components that are unrepresentative of real-world conditions. Once identified, ERDC STS personnel along with the hydrodynamic team and simulator manufacturer will work to modify components to create a realistic representation. Some examples of possible alterations include modifications to the visual scene, vessel models, hydrodynamics, bathymetry, or bank effects. Validation was completed on 9–11 February 2022 with two Mobile Bar Pilots who tested currents, vessel interaction, vessel handling, and the overall database.

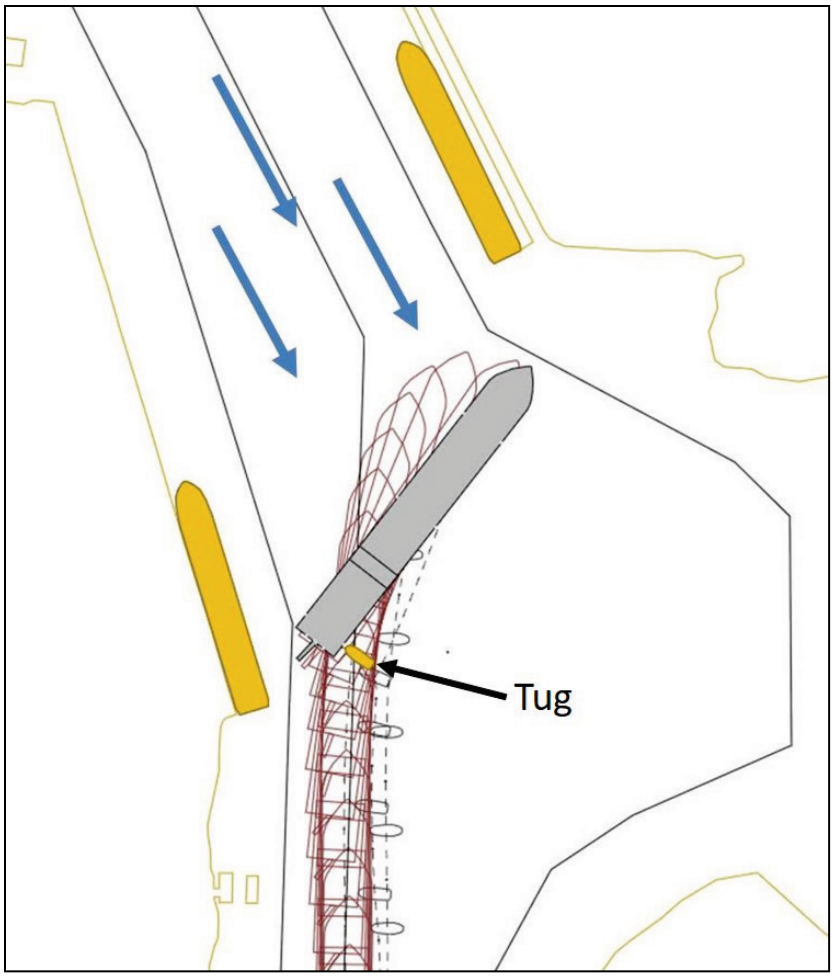
5.1 Currents

While currents were validated during the 2020 study, new currents were developed for this study. In the 2020 study, only one current set was tested in the turning-basin simulations: an increased ebb with northerly wind. A vessel turning in the Choctaw Pass Turning Basin blocks most of the Mobile River flow especially under ebb conditions, which causes the currents to intensify (Figure 38). Ship-simulator input requires a precalculated current field, so capturing this recalculation of currents to account for ship blockage is not currently available. To approximate this increased effect of currents, the Mobile River flow was increased in the hydrodynamic simulations until pilots felt the effect was representative. While this approach was appropriate for a turning maneuver, the currents were not appropriate for the approach or departure to the turning basin. Therefore, high (not increased) flood and ebb currents were created for this study, and no turning in the turning basin was performed (Table 5). Pilots were instructed to transit the channel as if they were performing a head-up berthing maneuver at the container terminal for all simulations.

Pilots tested all four existing condition current sets (ebb tide with north wind, ebb tide with east wind, flood tide with east wind, and flood tide with southeast wind) during validation (Table 8). A crosscurrent was identified near McDuffie Coal Terminal #1, which pilots expressed was unrealistic. The crosscurrent was particularly prominent in the ebb-tide conditions. After reviewing the numerical model mesh bathymetry, it was determined the area southwest of McDuffie Coal Terminal #1 was too deep and likely contributing to this issue. Hydrodynamics were rerun with

adjusted bathymetry in that area. Once completed, the currents were more aligned with the channel, and pilots stated they were more representative.

Figure 38. Turning vessel that blocks most of the Mobile River flow during ebb-tide conditions (Johnston et al. 2021. Public domain.).



5.2 Vessel Assessment

Vessel handling and response for the design vessel (CNTNR49) was assessed during the 2020 ship-simulation study. Pilots considered this model to be a realistic representation of a vessel of this size.

5.3 Vessel Interaction

During validation, pilots experienced an unrealistic shearing force between the transiting vessel and the vessel docked at McDuffie #2 (Figure 39). After additional simulations were completed to attempt to isolate the issue, it was determined the shearing occurred only when both

the currents and moored vessels were placed into the database. It was speculated that the shearing could be caused by increased ship-to-ship interaction coefficients in the vessel model files. The coefficients are nondimensional and used in calculating the forces and momentum due to longitudinal and lateral separation of ships. To temporarily test this theory, the ship-to-ship interaction coefficients for the transiting vessel and the moored vessels were set to zero. Pilots still experienced the shearing. Next, the bank-effect interaction coefficient was set to zero for all the simulated vessels. The bank-effect coefficient is used to control how strongly a vessel responds to a bank. When this value was set to zero, the shearing effect was drastically reduced to a response pilots expressed was realistic. On 11 February 2022, the ship-to-ship interaction coefficient values were reset to their original values, but the bank-effect values remained at zero. Pilots felt this response was still realistic with these settings, so these values were used for the remainder of the first set of simulations and for part of the second set of simulations (morning only on 16 February 2022).

After several discussions with the simulator manufacturer, it was determined that this shearing effect was caused by a defect in the ship simulator. Typically, the simulator uses the ship-to-ship interaction value for meeting (opposite heading) or overtaking (same heading) situations where both vessels are traveling at similar speeds. The simulator uses the bank-effect value to react to channel geometry and any nonmoving solid body near the ship, which includes moored vessels. However, the scenarios tested in this study included a more complex interaction where both interactions were involved due to the currents. While the moored vessels were stationary in terms of the shore, they are moving through the water due to the currents, thus generating a water-pressure field and flow around them. This combined scenario is more difficult to approximate and less studied by the hydrodynamic community. The simulator attempts to use a weighted transition between traditional bank-effect interaction and ship-to-ship interaction calculations. In the case of these vessel models, that transition was initially improperly represented. The vessel model manufacturer provided modified vessel model files, which adjusted these calculations the afternoon of 16 February 2022. These modified files were used for the remaining days of simulations. While the zero-bank-effect simulations completed on 11 February and 16 February did record some surge and sway, they should be considered nonconservative as no-bank-effect calculations were included.

Pilots agreed that the overall existing condition database was a realistic approximation of the current operations in Mobile Harbor. Once the existing condition model was validated, production runs, or simulations of the proposed modifications, began.

Figure 39. Example of vessel shearing that occurred near McDuffie #2 during validation.



6 Results

This section discusses the results for the proposed-condition simulations. The channel-design alternatives are presented in the following order: P3 (+100 ft original expansion), P2A (+50 ft modified expansion), P75 (+75 ft modified expansion), and P3A (+100 ft modified expansion). In each alternative section, inbound transits are discussed first, followed by outbound transits.

Results are presented in the form of track plots (Appendix A), informational sheets (Appendix A), graph sheets (Appendix A) and final pilot questionnaires (Appendix B). Track plots for all the proposed-condition simulations are in Appendix A designated by plates. Each plate contains condition information (*bottom-right corner*), transiting-vessel dimensions (*bottom-left corner*), docked-vessel dimensions (*top-left corner*), and the track plots for a scenario. Track plots are colored by pilot number (pilot 1 in *red*, pilot 2 in *green*, pilot 3 in *blue*, and pilot 4 in *peach*).

Each plate is followed by an informational sheet and a graph sheet. The informational sheet contains conditions tested, pilot comments and pilot scores that were filled out after each run, data related to the docked vessels at the McDuffie Coal Terminal berths, and a summary table highlighting tension and movement failures. Vessel distances were measured from the midship of the transiting vessel to midship of the berthed vessel at each of the McDuffie Coal Terminal berths. When this distance was recorded, a vessel speed for the transiting vessel was also recorded. On the informational sheet, the midship-to-midship distance is labeled as vessel distance, and the transiting vessel speed is labeled as SOW (speed through the water). While there are not strict safety requirements for speeds near the McDuffie Coal Terminal, the Mobile Bar Pilots were able to identify a *rule-of-thumb* that should be followed. The pilot rule is for the transiting vessel to go 6 kn or fewer when maneuvering by the docked vessels at the McDuffie Coal Terminal berths.

The graph sheet contains surge-versus-sway graphs for each docked vessel and the maximum line tension recorded for that simulation. The surge and sway graphs feature a *red box* to distinguish the movement thresholds (±3 ft for surge or sway). If data are shown outside this red box, the surge-sway movement threshold was exceeded, and the simulation was designated as a failure. Surge values are defined as positive in the forward

direction, and sway values are defined as positive to starboard. The maximum tension graph includes a *dashed red line* to designate the 50% minimum breaking load for each of the mooring lines in the simulation. This threshold was selected based on the Oil Companies International Marine Forum Mooring Equipment Guidelines published in 2018 (Intertanko 2019). The maximum-tension graph is shown in terms of percentages so that all lines could be presented in a single graph. The head and stern lines have a higher maximum tension permitted as they represent four lines while all other lines represent two lines each. If a maximum tension was recorded that exceeded this 50% minimum breaking load, the simulation was designated as a failure. If either the surge, sway, or tension threshold was exceeded during a simulation, it was considered a failure.

A test matrix consisting of eight unique scenarios was established for each alternative (Table 10). Because of limited testing time, not all these scenarios were completed for each alternative. Table 11 presents information for the 52 proposed-condition simulations conducted. The leftmost column designates the corresponding plate number in Appendix A. Some plate numbers are repeated with a *B* following the number. This designates that the conditions are the same as the previous plate, but a different vessel was docked at McDuffie #2. All proposed-condition simulations featured vessels docked at McDuffie #1, #2, and #3 except for the repeated Run 48 (Plate 17), which had only one vessel docked at McDuffie #2. Pilots 1 and 2 completed simulations in P3. Pilots 3 and 4 completed simulations in P2A, P75, and P3A.

In shallow water, a moving vessel can experience the squat effect that causes the vessel to sit lower in the water column than it would if stationary. The reduction of pressure beneath the vessel and the decrease of under keel clearance can be explained by Bernoulli's Theorem. A small amount of additional water depth in the form of additional tide was added to simulations to compensate for an overestimate of squat that typically occurs in the ship simulator. All simulations featured an additional +0.5 m of additional tide except for Run 9 completed by Pilot 1 (Plate 1), which featured +1.5 m of added tide. All simulations were completed with the CNTNR49 as the transiting vessel and one center-lead aft 60 T tugboat available to assist with ship maneuvering. The tugboat usage was determined by the transiting pilot. The tugboat was controlled by

operators in real time according to pilot commands. The tugboat is not included in any of the track plots presented in Appendix A, to limit clutter.

Many simulations were completed with the VLCC13P docked at McDuffie #2 since it was not identified until the middle of testing that the VLCC13P was recording minimal surge and sway movement. As confirmed by the simulator manufacturer, the movement calculations recorded from the VLCC13P were from an outdated surge-sway computation that needed to be updated and replaced. Therefore, a specific column is included in Table 11, on the track plots, and in the McDuffie information table on the informational sheet to clearly highlight which vessel was docked at McDuffie #2.

Table 10. Run scenarios for each alternative.

Heading	Vessel Model	Tide	Wind
Inbound	CNTNR49	Ebb	20 kn, N
Inbound	CNTNR49	Ebb	20 kn, E
Inbound	CNTNR49	Flood	20 kn, E
Inbound	CNTNR49	Flood	20 kn, SE
Outbound	CNTNR49	Ebb	20 kn, N
Outbound	CNTNR49	Ebb	20 kn, E
Outbound	CNTNR49	Flood	20 kn, E
Outbound	CNTNR49	Flood	20 kn, SE

Table 11. All proposed-condition simulations completed.

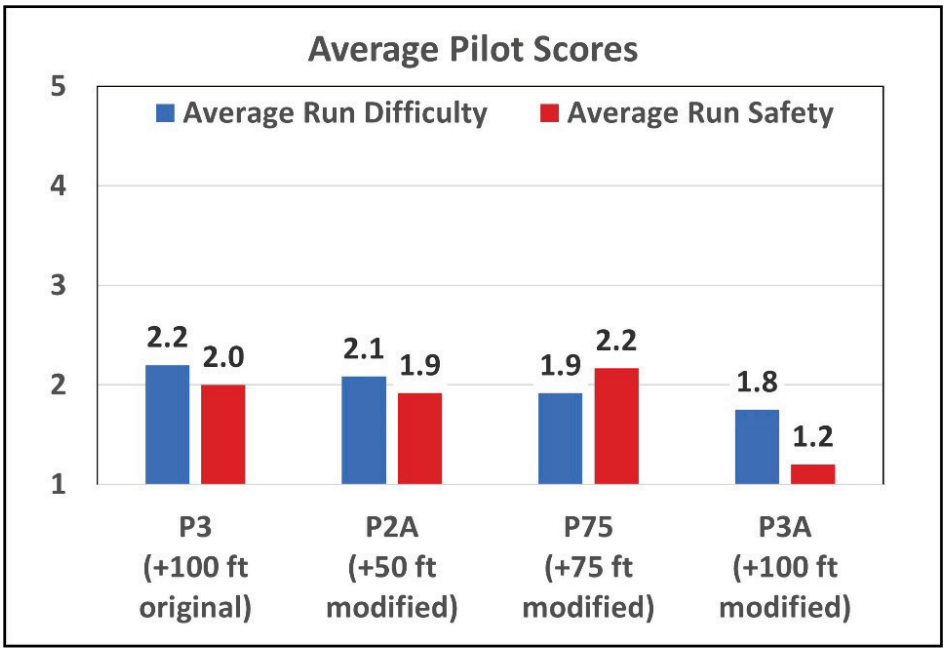
Plate # in Appendix A	Alternative	Heading	Current	Wind	Pilots Completed	McDuffie #2	Run #
1	P3	Inbound	Ebb	20 N	1, 2	VLCC13P	9
2	P3	Inbound	Ebb	20 E	1, 2	VLCC13P	11
3	P3	Outbound	Flood	20 E	1, 2	VLCC13P	14
4	P3	Outbound	Flood	20 SE	1, 2	VLCC13P	16
5	P2A	Inbound	Ebb	20 N	3, 4	VLCC13P	25
6	P2A	Inbound	Ebb	20 E	3, 4	VLCC13P	27
7	P2A	Inbound	Flood	20 SE	3	BULKC19	31
8	P2A	Outbound	Ebb	20 N	3	VLCC13P	26
8B	P2A	Outbound	Ebb	20 N	3	BULKC19	26
9	P2A	Outbound	Ebb	20 E	4	VLCC13P	28
10	P2A	Outbound	Flood	20 E	3, 4	VLCC13P	30
11	P2A	Outbound	Flood	20 SE	3, 4	VLCC13P	32

Table 11 (cont.). All proposed-condition simulations completed.

Plate # in Appendix A	Alternative	Heading	Current	Wind	Pilots Completed	McDuffie #2	Run #
12	P75	Inbound	Ebb	20 N	3, 4	VLCC13P	41
13	P75	Inbound	Ebb	20 E	3, 4	VLCC13P	43
14	P75	Outbound	Ebb	20 N	3, 3	BULKC19	42
15	P75	Outbound	Ebb	20 E	3, 4	BULKC19	44
16	P75	Outbound	Flood	20 E	3, 4	BULKC19	46
17	P75	Outbound	Flood	20 SE	3, 3	BULKC19	48
18	P3A	Inbound	Ebb	20 N	3, 4	VLCC13P	33
18B	P3A	Inbound	Ebb	20 N	3, 4	BULKC19	33
19	P3A	Inbound	Ebb	20 E	3, 4	VLCC13P	35
19B	P3A	Inbound	Ebb	20 E	3, 4	BULKC19	35
20	P3A	Inbound	Flood	20 SE	3	BULKC19	39
21	P3A	Outbound	Ebb	20 N	3, 4	BULKC19	34
22	P3A	Outbound	Ebb	20 E	3, 4	BULKC19	36
23	P3A	Outbound	Flood	20 E	3, 4	VLCC13P	38
23B	P3A	Outbound	Flood	20 E	3, 4	BULKC19	38
24	P3A	Outbound	Flood	20 SE	3, 3, 4	BULKC19	40

Following each simulation, the pilots were asked to fill out a run sheet with their comments about the run and to provide a pilot score for run difficulty and run safety. Pilot scores are ranked from 1 to 5 with low scores indicating a safer and less-difficult transit. Average pilot scores for all completed simulations are shown in Figure 40. Average run difficulty scores ranged from 2.2 (P3) to 1.8 (P3A). Average run safety scores ranged from 2.2 (P75) to 1.2 (P3A).

Figure 40. Pilot score breakdown for the various alternatives tested. Lower scores equate to safer, less-difficult transits.



6.1 P3 Simulations

Plate 1–Plate 4 show track plots from the eight simulations completed in P3 (+100 ft original transition). Track plots for inbound ebb simulations are shown on Plate 1 and Plate 2. Track plots for two simulations completed with north wind are featured in Plate 1. In the simulation completed by Pilot 2, the vessel docked at McDuffie #1 exceeded both surge and sway thresholds. The simulation completed by Pilot 1 was successful based on the docked vessels not exceeding surge, sway, and tension thresholds. Pilot 2 was traveling approximately 0.6 kn faster and 118 ft farther east than Pilot 1 near the McDuffie Coal Terminal. Note that the simulation with Pilot 1 had an additional 1.5 m of tide versus 0.5 m for all other simulations. The additional water depth increases the underkeel clearance and it is expected to reduce passing ship impacts on docked vessels.

Plate 2 contains track plots from two simulations featuring east wind. Both simulations were unsuccessful. The simulation completed by Pilot 1 exceeded movement (McDuffie #1) and tension thresholds (McDuffie #1 and #3). The simulation completed by Pilot 2 exceeded only movement thresholds (McDuffie #1). Pilot 2 was traveling approximately 0.3–0.5 kn faster and farther east than Pilot 1 near the McDuffie Coal Terminal. Both pilots were transiting at high speeds (greater than 7.2 kn through the water), which exceeds the pilot vessel-speed rules.

Track plots for outbound flood simulations are shown on Plate 3 and Plate 4. Plate 3 features track plots from two simulations with east wind. The simulation completed by Pilot 1 was successful. The simulation completed by Pilot 2 exceeded the movement threshold and nearly exceeded tension thresholds (49.6% MBL) at McDuffie #1. Both pilots transited along similar vessel paths; however, Pilot 2 was traveling approximately 0.9 kn faster than Pilot 1 near McDuffie #1. Plate 4 features track plots from two simulations with southeast wind. Pilot 1 transited closer to the channel centerline compared to Pilot 2 who took an easterly approach to maximize use of the widener. Both simulations exceeded movement thresholds at McDuffie #1. Tension thresholds (forward breast and additional stern lines) were exceeded at McDuffie #1 in the simulation completed by Pilot 1 and nearly exceeded (49.8% at forward breast line) for Pilot 2.

6.2 P2A Simulations

Plate 5–Plate 11 show track plots from the 12 simulations completed in P2A (+50 ft modified transition). Track plots for inbound ebb simulations are shown on Plate 5 and Plate 6. Track plots for two simulations completed with north wind are featured on Plate 5. The simulation completed by Pilot 4 was successful. The simulation completed by Pilot 3 exceeded surge-sway movement and tension thresholds (additional stern line) at McDuffie #1. Both pilots were traveling at high speeds (greater than 6.8 kn) while Pilot 3 was approximately 105 ft closer to McDuffie #1 than Pilot 4. Plate 6 features track plots from two simulations with east wind. Similar to Plate 5, the simulation completed by Pilot 4 was successful while Pilot 3's simulation exceeded sway movement and tension thresholds (additional stern line) at McDuffie #1. Both pilots were traveling at high speeds (greater than 6.7 kn) while Pilot 3 was approximately 120 ft closer to McDuffie #1 than Pilot 4.

Plate 7 contains a track plot from an inbound simulation completed with a flood tide and southeast wind. No failure thresholds were exceeded for this simulation.

Plate 8 contains a track plot from an outbound simulation completed with an ebb tide and with north wind. The simulation exceeded movement and tension thresholds at McDuffie #1 and #3. It also features the largest recorded surge (7.5 ft) and sway (13.7 ft) for McDuffie #1. The data

captured in this simulation indicated the forward breast and additional stern lines exceeded the minimum breaking load, and these lines broke during the simulation (Figure 41). The line breakages along with the momentum of the affected vessel likely led to this high exceedance.

Figure 41. Line tension recorded for Run 26.

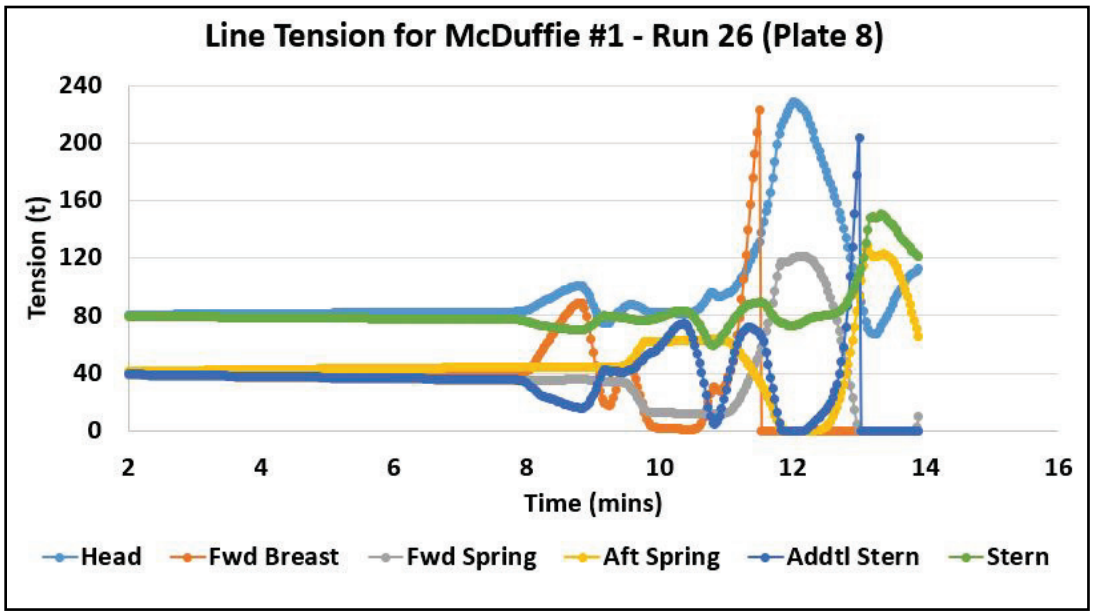


Plate 8B contains a track plot with the same conditions as Plate 8; however, the vessel at McDuffie #2 was changed from VLCC13P to BULKC19. The simulation from Plate 8 showed little movement for the VLCC13P despite significantly large movement of the adjacent docked vessels. The simulation from Plate 8B exceeded movement and tension (forward breast line) thresholds at McDuffie #2. Subsequent simulations were run with the BULKC19 docked at McDuffie #2 to be conservative.

Plate 9 contains a track plot from an outbound simulation completed with an ebb tide with east wind. The simulation exceeded movement (sway) and tension (aft breast) thresholds at McDuffie #3. The passing vessel was traveling at approximately 3.4 kn through the water (5.4 kn over ground) and 228 ft from the docked vessel (midship to midship) at McDuffie #3.

Plate 10 features track plots from two outbound simulations completed with flood tide and east wind. The simulation completed by Pilot 3 exceeded movement thresholds at McDuffie #1. The simulation with Pilot 4 exceeded tension threshold (aft breast line) at McDuffie #3. Both

pilots transited along similar vessel paths however Pilot 4 was traveling 1.1 kn faster near McDuffie #3.

Plate 11 contains track plots from two outbound flood simulations with southeast wind. The simulation completed by Pilot 3 was successful. The simulation completed by Pilot 4 exceeded the surge movement threshold and nearly exceeded the tension (48% MBL) threshold at McDuffie #1. Pilot 4 was traveling 1.3 kn faster than Pilot 3 near McDuffie #1.

6.3 P75 Simulations

Plate 12–Plate 17 show track plots from the 12 simulations completed in P75 (+75 ft modified transition). Track plots for inbound ebb simulations are shown on Plate 12 and Plate 13. Track plots for two simulations completed with north wind are featured on Plate 12, and both simulations remained under movement and tension thresholds. Pilot 4 was transiting at a high speed, approximately 7.1 kn through the water, which exceeds pilot guidelines for the area. However, the pilot transited on the far-east side of the channel. This easterly approach kept the transiting vessel far away from the docked vessels at the McDuffie Coal Terminal (approximately 350 ft midship to midship), which appears to have caused the limited surge and sway movement response from the docked vessels. Pilot 3 transited more towards the channel centerline at lower speeds (4.6 kn through the water). While the winches were released late (around 6 min into the simulation), they were released well before the transiting vessel interacted with any docked vessels.

Plate 13 features track plots from two simulations with east wind. Although Pilot 4 transited at a high speed (approximately 7.2 kn through the water), he took a far easterly approach that kept the transiting vessel far away from the docked vessels at the McDuffie Coal Terminal (approximately 380 ft midship to midship). While the docked vessels did not exceed the movement thresholds, McDuffie #1 was close to exceeding (−2.8 ft in maximum sway). The vessel path taken by Pilot 3 meandered from the west side of the channel to the east. This was likely caused by a slightly more pronounced set to starboard that occurred near the southern end of the McDuffie Coal Terminal that the pilot noted in his comments. No failure thresholds were exceeded for this simulation.

Plate 14–Plate 17 show track plots from outbound ebb (Plate 14 and Plate 15) and flood (Plate 16 and Plate 17) simulations. Plate 14 contains track plots from two simulations with north wind that were completed by Pilot 3. A large portion of the data for the first simulation completed by Pilot 3 was lost. The vessel location information was able to be recovered so the track plot shows the full transit; however, most of the tension and docked movement data from the first 14 min of the simulation were not recoverable. While the maximum surge and sway movements are presented for McDuffie #1, #2, and #3 based on the data that were salvageable, these are not likely the true maximums as data were only available after the transiting vessel was approximately passing McDuffie #1. However, the available data did show that the vessel movement threshold was exceeded at McDuffie #1. In the repeated run, Pilot #3 takes a similar path as his first transit but travels at a slightly higher speed. Note that for any outbound ebb simulations speed over the ground would be approximately 2 kn higher than speed through the water. In this repeated run, the docked movement threshold was exceeded at McDuffie #2. Although the tension threshold was not exceeded, the forward breast line at McDuffie #2 was very close (approximately 47% MBL).

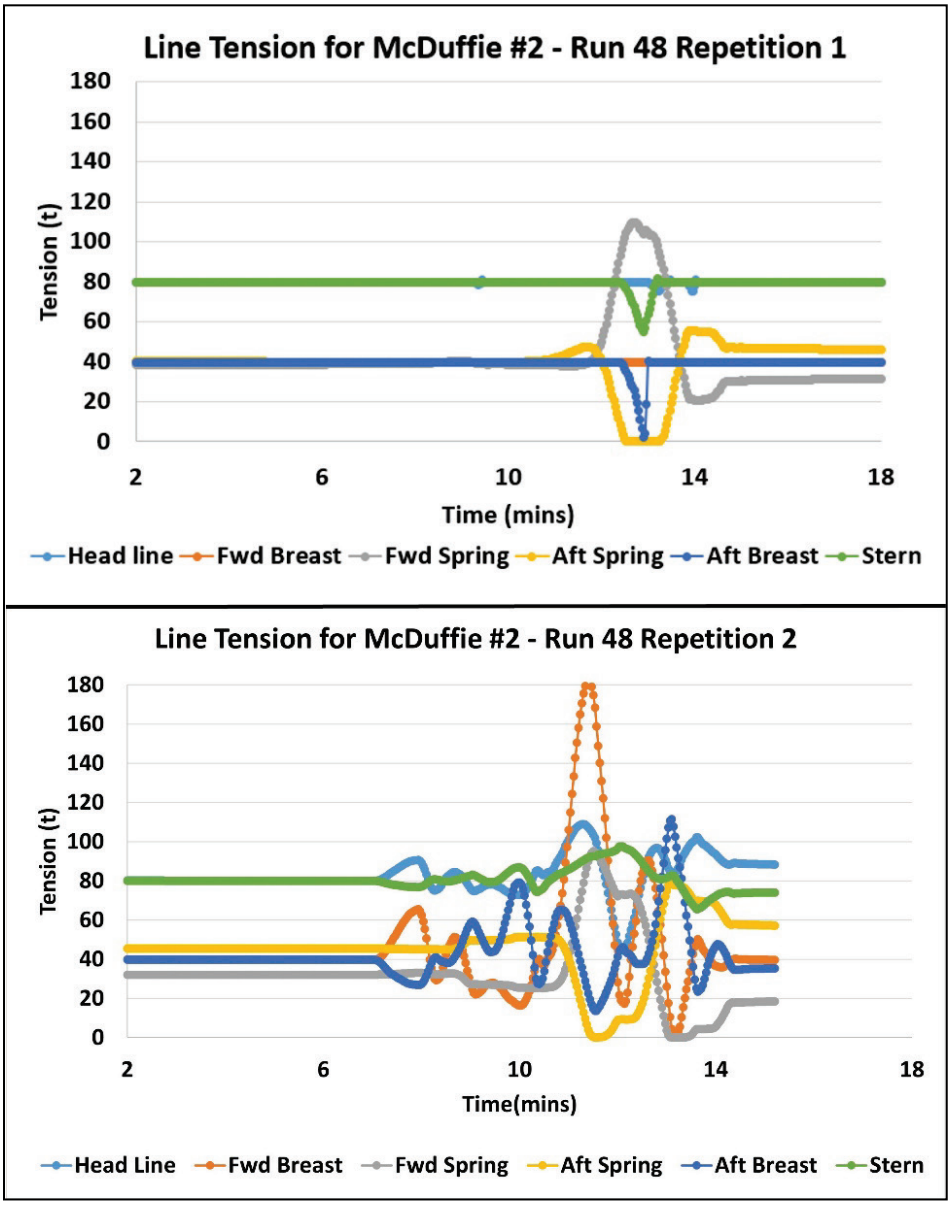
Plate 15 contains track plots from two simulations featuring ebb tide and east wind. Pilot 3 and Pilot 4 transited along similar vessel paths near the McDuffie Coal Terminals. The simulation completed by Pilot 3 was successful. The simulation completed by Pilot 4 exceeded movement (McDuffie #2) and tension thresholds (McDuffie #2 and #3). Pilot 4 was traveling approximately 0.8 kn faster than Pilot 3 near the McDuffie Coal Terminal.

Plate 16 contains track plots from two simulations completed with flood tide and east wind. The simulation completed by Pilot 3 did not exceed tension thresholds but did slightly exceed movement thresholds (–3.2 ft of maximum sway). The simulation completed by Pilot 4 exceeded movement and tension thresholds (forward breast lines) for McDuffie #1 and #2. Pilot 4 was traveling approximately 1 kn faster and 30 ft farther west than Pilot 3 near the McDuffie Coal Terminal.

Plate 17 features track plots from two simulations completed by Pilot 3 that had southeast wind. It became clear after reviewing these data that the winches were accidentally not released on the mooring lines for the first simulation completed by Pilot 3. With the winches connected, the

lines are lengthened or shortened to maintain a constant specified tension. Winches were connected to the head, forward breast, aft breast, and stern lines. Figure 42 plots the line tension for repetition 1 (winches not released) and repetition 2 (winches released approximately 1 min into the simulation). While the tension in the spring lines vary in repetition 1 (no winches attached), the other lines (head, breast, and stern) recover quickly to the match the constant specified tension. In repetition 2, the line tension largely varies throughout the simulation. In the repeated run, only a BULKC19 was docked at McDuffie #2. The movement and tension thresholds (forward breast) were exceeded.

Figure 42. Line tension recorded for Run 48. Winches were not released in repetition 1.



6.4 P3A Simulations

Plate 18–Plate 24 show track plots from the 20 simulations completed in P3A (+100 ft modified transition). Track plots for inbound ebb simulations are shown on Plate 18–Plate 19B. Plate 18 features track plots from two simulations completed with ebb tide, north wind, and the VLCC13P docked at McDuffie #2. Pilot 4 transited on the far-east side of the channel (approximately 390 ft midship to midship) while Pilot 3 transited more towards the center of the expanded channel (approximately 220 ft midship to midship). While transiting speeds were high (approximately 5.8 kn for Pilot 3 and approximately 6.6 kn for Pilot 4), no failure thresholds were exceeded for either simulation. Track plots shown in Plate 18B were completed under the same conditions as Plate 18 except the BULKC19 was docked at McDuffie #2. Pilots took similar approaches as in Plate 18 with Pilot 4 transiting farther east (approximately 384 ft midship to midship) than Pilot 3 (approximately 328 ft midship to midship). No failure limits were exceeded for these simulations.

In Plate 19, track plots from two simulations completed with ebb tide, east wind, and the VLCC13P docked at McDuffie #2 are presented. Pilot 3 traveled slower than Pilot 4 (approximately 5.1 kn and 6.0 kn through the water, respectively), but the pilots took similar approaches. While the winches were released late (approximately 10 min after the simulation began) during the simulation completed by Pilot 4, they were released prior to the vessel passing McDuffie #1. Both simulations were successful.

Track plots shown in Plate 19B were completed under the same conditions as Plate 19 except the BULKC19 was docked at McDuffie #2. Pilot 3 completed a winding path near the McDuffie Coal Terminal while Pilot 4 transited on the far-east side of the channel. Both transits featured large midship to midship distances (approximately 341 ft for Pilot 3 and 417 ft for Pilot 4). Neither movement nor tension thresholds were exceeded in these simulations.

Plate 20 features track plots from one inbound simulation with flood tide and southeast wind. Pilot 3 transited slightly east of the channel centerline near the McDuffie Coal Terminal berths (approximately 287 ft midship to midship). Movement and tension maximums did not exceed the failure limits for this simulation.

Plate 21–Plate 24 show track plots from outbound ebb (Plate 21 and Plate 22) and flood (Plate 23–Plate 24) simulations. Plate 21 contains track plots from two simulations with north wind. Pilot 3 transited on the far-east side of the channel (approximately 351 ft midship to midship) while Pilot 4 transited more towards the center of the expanded channel (approximately 240 ft midship to midship). The simulation that was completed by Pilot 3 did not exceed failure thresholds. However, the simulation completed by Pilot 4 did exceed movement and tension thresholds at all the McDuffie Coal Terminal Berths. Pilot 4 commented that he had to strongly back the tug and start and stop his engines to keep the transiting speeds low. This simulation featured the largest amount of surge recorded for McDuffie #2 and McDuffie #3 in all the simulations completed. This large movement was likely attributed to line breakages that occurred on the forward breast line at McDuffie #2 and the aft breast line at McDuffie #3.

Plate 22 contains track plots from two simulations completed with ebb tide and east wind. Pilot 3 and Pilot 4 followed similar vessel paths. The simulation completed by Pilot 3 did not exceed failure thresholds. However, the simulation completed by Pilot 4 did exceed movement and tension thresholds (forward breast lines) for McDuffie #2.

Plate 23 features track plots from two simulations completed with flood tide, east wind, and the VLCC13P docked at McDuffie #2. Pilot 4 transited farther east, especially near McDuffie #1, compared to Pilot 3. While winches were released late (approximately 1 min 45 s into the simulation), it occurred well before the transiting vessel was near the McDuffie Coal Terminal. Both simulations were successful.

Plate 23B contains track plots from two simulations completed with flood tide, east wind, and the BULKC19 docked at McDuffie #2. Pilot 3 and Pilot 4 took similar vessel paths in these simulations (approximately 342 ft and 389 ft midship to midship distances for Pilot 3 and Pilot 4, respectively). The movement and tension maximums did not exceed the failure limits for these simulations.

Plate 24 presents track plots from three simulations completed with flood tide and southeast wind. In the first attempt made by Pilot 3, the outbound approach was too far east, and the vessel exceeded the channel limits next to Little Sand Island where the channel narrows. The simulation was stopped. This was the last run of the day for this pilot. He repeated the run

the following morning and took an approach more towards the channel centerline (approximately 284 ft midship to midship). However, this simulation did slightly exceed surge and sway movement thresholds for McDuffie #2 (3.4 ft maximum surge and –3.1 ft maximum sway). Tension limits were not exceeded for this simulation. The vessel path taken by Pilot 4 was between the two different approaches taken by Pilot 3 (approximately 401 ft midship to midship). No failure limits were exceeded for that simulation.

7 Production Runs Additional Discussion

After the ship simulations were completed, a review of the results was accomplished. This section provides information about the overall success rates grouped by alternative and conditions; a description of failure modes and their locations; and trends of surge and sway movement, speed, and midship-to-midship distance by alternative and heading conditions.

7.1 Success Rates

A simulation was considered successful if the tension threshold and surge-sway movement threshold were not exceeded for any of the three vessels docked at the McDuffie Coal Terminal berths. Figure 43 presents the success rates for each alternative tested in the ship simulator. Alternative P3 had the lowest success rate at only 25% (2 out of 8 simulations performed) while P3A had the highest success rate at 85% (17 out of 20 simulations performed). Figure 44 features a further breakdown of success rates by alternative and run conditions. Note the number of simulations performed for each alternative and run condition varied. Text was included on this figure to denote the number of successful runs out of the total runs performed in the alternative and run-condition pairing. In general, there were more failures in the outbound runs than the inbound runs (67% success rate for inbound versus 37% success rate for outbound).

Figure 43. Overall success rates for each alternative.

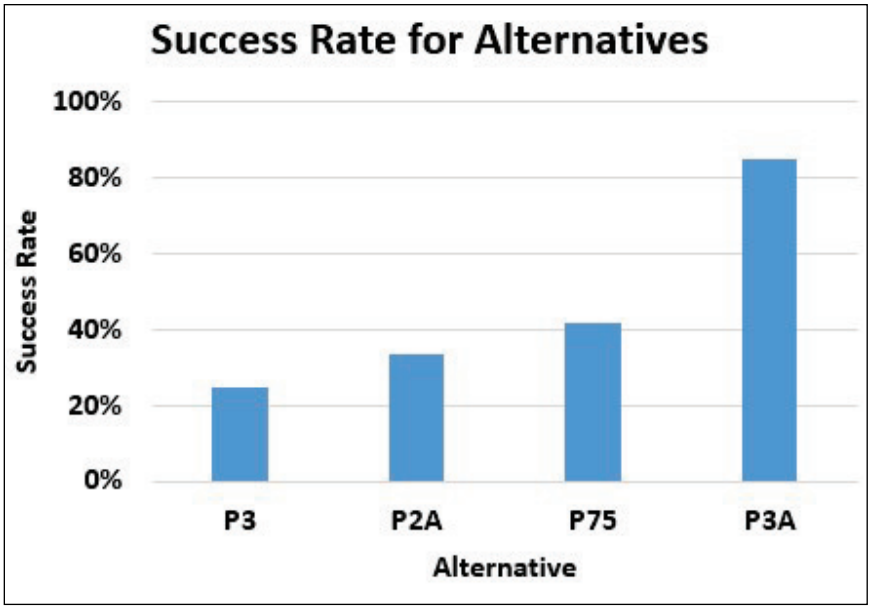
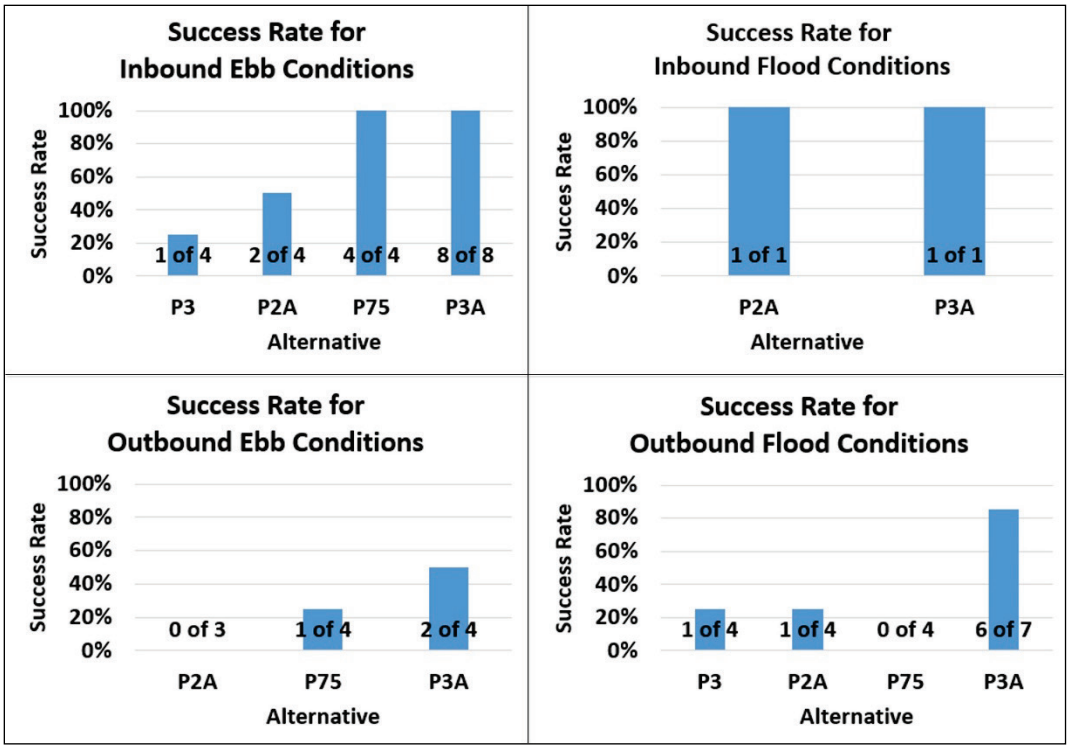


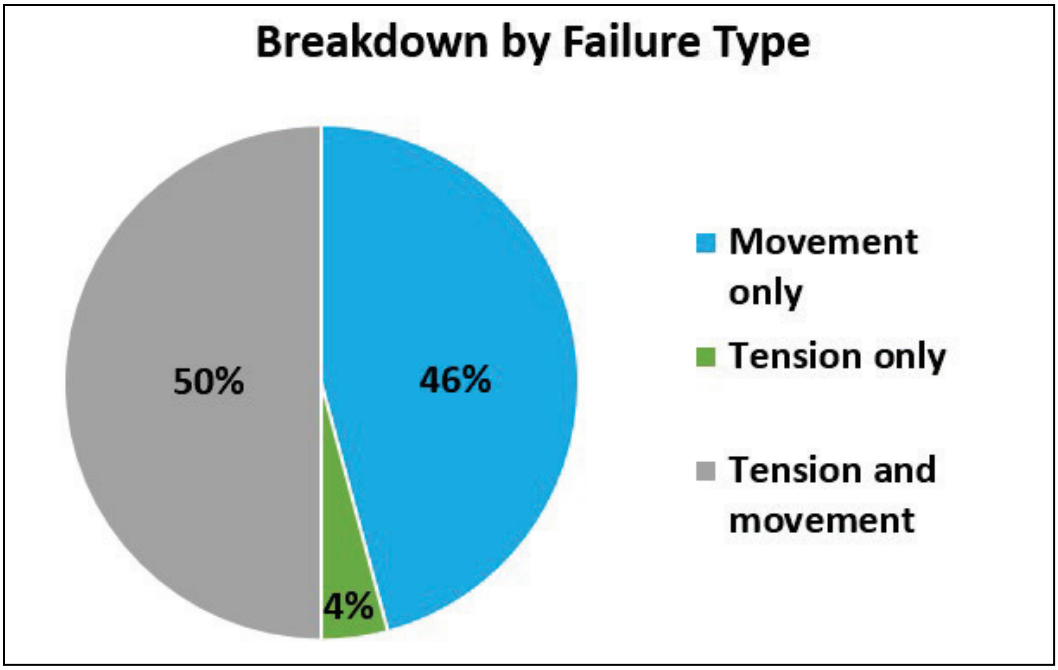
Figure 44. Overall success rates for each alternative broken down by condition.



7.2 Description of Failures

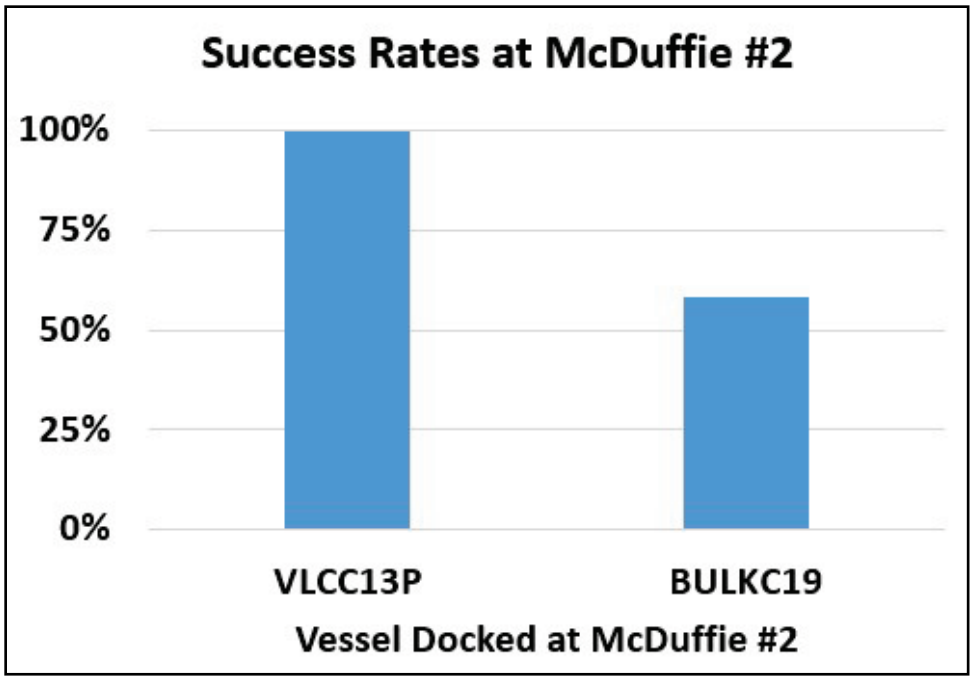
During testing, 52 proposed-condition simulations were performed (8 in P3, 12 in P2A, 12 in P75, and 20 in P3A). There were 24 simulations that exceeded thresholds in tension (1), movement (11), or both (12) (Figure 45). Typically, tension and movement failures were closely paired. In most of the simulations that featured a movement-only failure, the tension threshold was close to exceeding. In one case, the winches were not released, which caused the tension to be held constant for the lines attached. In the one simulation that featured a tension-only failure (Plate 10), the movement in sway was close to exceeding its limit.

Figure 45. Breakdown of failure type.



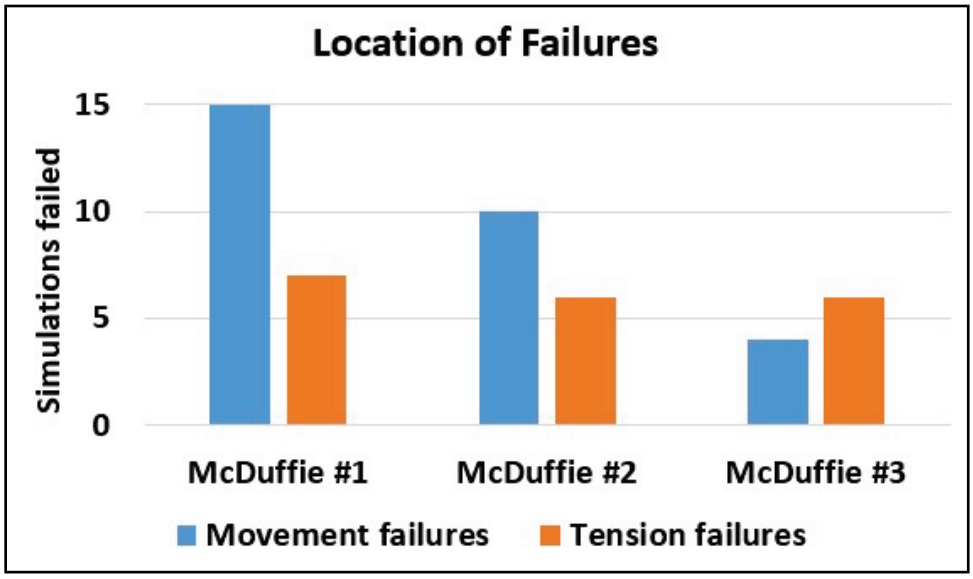
When reviewing the results, note that simulations completed with the VLCC13P docked should be heavily caveated for McDuffie #2 results as it was determined that its movement calculations were from an outdated formulation. The importance of the vessel docked at McDuffie #2 is highlighted in Figure 46. When the VLCC13P was docked at McDuffie #2, no failures at that dock occurred (28 successful simulations). The success rate dropped to approximately 58% at McDuffie #2 with the BULKC19 (14 out of 24 simulations). It is expected these vessels should have had similar success rates, so it is anticipated this difference occurred due to the outdated movement calculations. Therefore, McDuffie #1 and McDuffie #3 were focused on for the surge-sway, midship-to-midship distance, and vessel speed trends discussed later in this section.

Figure 46. Success rates at McDuffie #2 by docked vessel.



Most of the movement failures occurred at McDuffie #1 followed by McDuffie #2 and then McDuffie #3 (Figure 47). Four simulations featured movement failures at more than one McDuffie Coal Terminal berths. Tension failures occurred approximately evenly across the three terminals. Five simulations featured tension failures at more than one McDuffie Coal Terminal berth.

Figure 47. Location of movement and tension failures.



Of the movement failures that occurred, most featured exceedance in both surge and sway (65%) (Figure 48). When tension maximums were exceeded (13), 85% of the failures occurred in either the forward breast lines, additional stern and aft breast lines, or both (Figure 49). In the two simulations that featured other lines that exceeded the tension thresholds, both contained broken lines.

Figure 48. Breakdown of movement failure type.

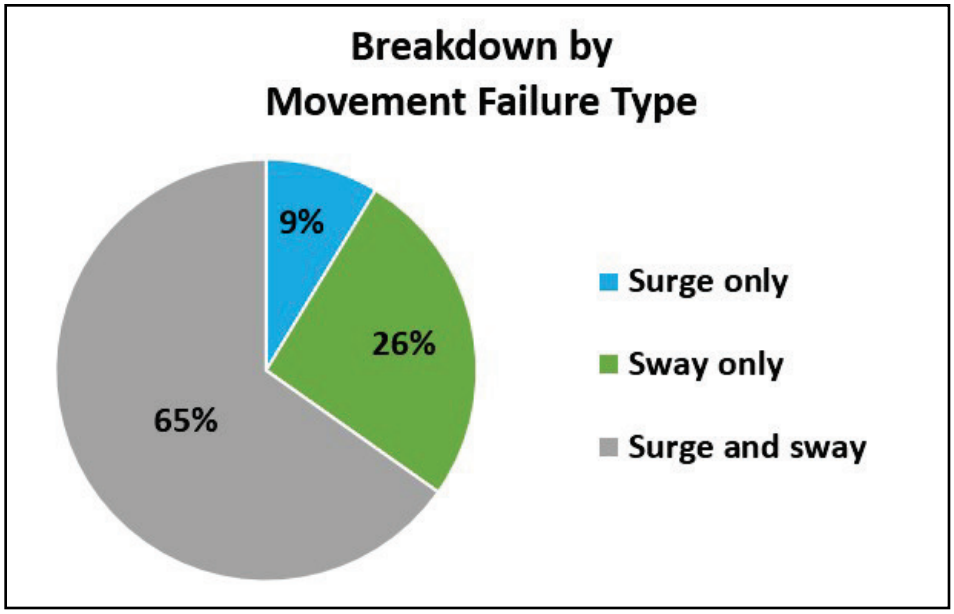
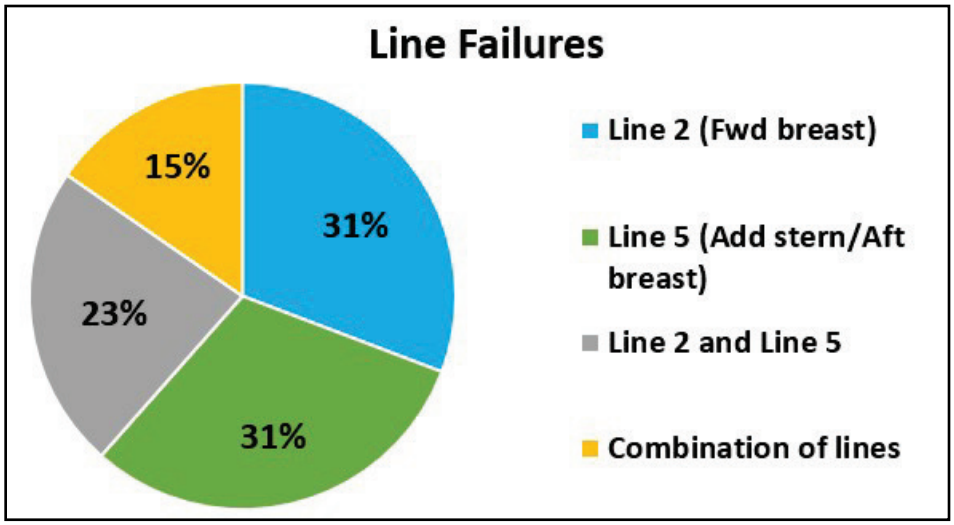


Figure 49. Breakdown of line failures.



7.3 Surge and Sway

The maximum cumulative movement (in surge and sway) was recorded for each simulation for each of the docked vessels. McDuffie #2 was not analyzed because of the heavily influenced results based on the docked vessel (VLCC13P versus BULKC19). The docked vessels movement values were recorded in absolute value, so the direction of the movement was not included. These maximums were then averaged to determine trends across the channel alternatives.

Figure 50 presents the average maximum midship-to-midship distances for the inbound simulations at McDuffie #1 (*top image*) and McDuffie #3 (*bottom image*). In these figures, surge and sway generally decrease or plateau across the modified alternatives (P2A, P75, and P3A). McDuffie #3 shows much less movement than the vessel at McDuffie #1. The largest maximum movement occurred at McDuffie #1 in the P3 alternative.

Figure 50. Average maximum distance for inbound conditions.

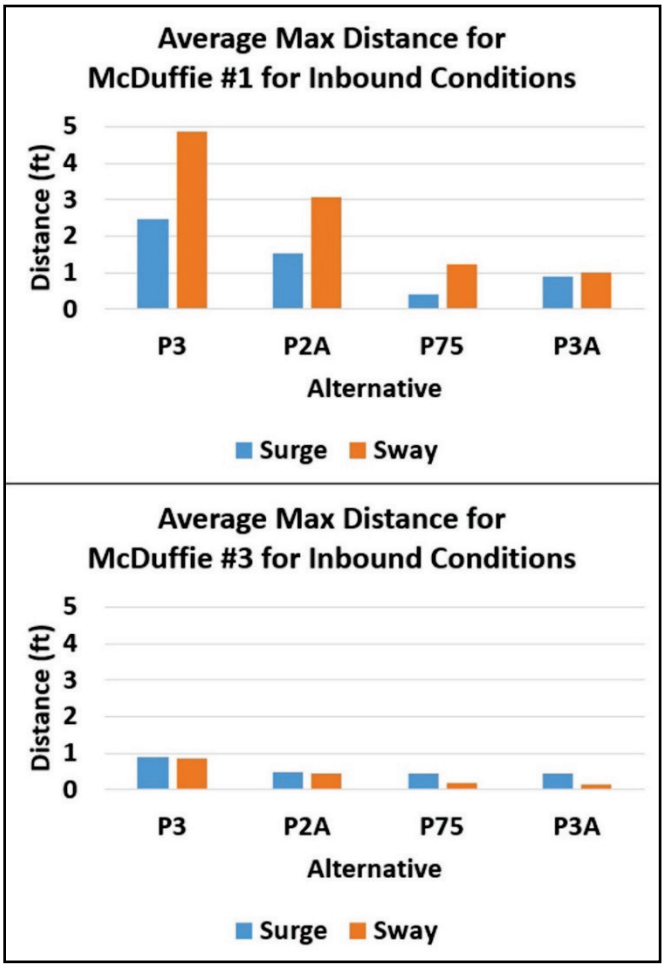
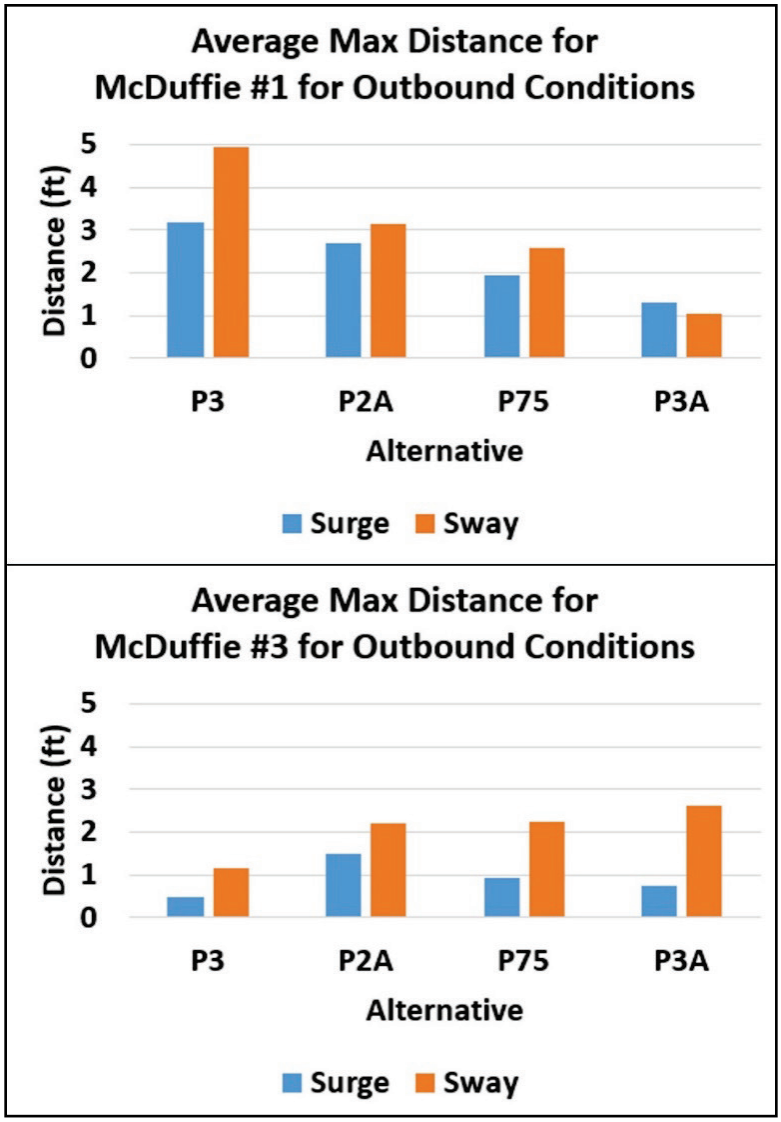


Figure 51 presents the average maximum distances for the outbound simulations at McDuffie #1 (*top image*) and McDuffie #3 (*bottom image*). In the McDuffie #1 figure, surge and sway decrease across the alternatives (P3, P2A, P75, and P3A). In the McDuffie #3 image, P3 shows the smallest average maximum movement. This is partially due to an incorrect starting position on half of the runs, which caused the pilots to have a substantial easterly approach, which put the transiting vessel far from McDuffie #3 (at least 390 ft midship to midship). This large distance from McDuffie #3 limited the surge and sway movement of the docked vessel. The largest maximum sway movement for these conditions occurred in P3A. This was due to one extreme run that was an outlier in terms of maximum sway (19 ft) due to a line breakage.

Figure 51. Average maximum distance for outbound conditions.



7.4 Speed and Distances

The midship-to-midship distances (transiting vessel to docked vessel) were recorded by the operator during simulations. The operator recorded the transiting vessel's speed through the water at the same location as the midship-to-midship distance. These values were recorded for all three McDuffie Coal Terminal berths. These distances and speeds were then averaged to determine trends across the alternatives.

Figure 52 presents the average vessel distance near McDuffie #1 (*top image*) and McDuffie #3 (*bottom image*). In these figures, vessel distances generally increase across the modified alternatives (P2A, P75, and P3A). In the P3 channel, pilots were able to utilize a noticeable percentage of the 100 ft expansion by maintaining farther distances from the docked vessels. However, that utilization of the expansion was paired with higher transiting speeds.

Figure 52. Average mid-ship to mid-ship distances across the alternatives.

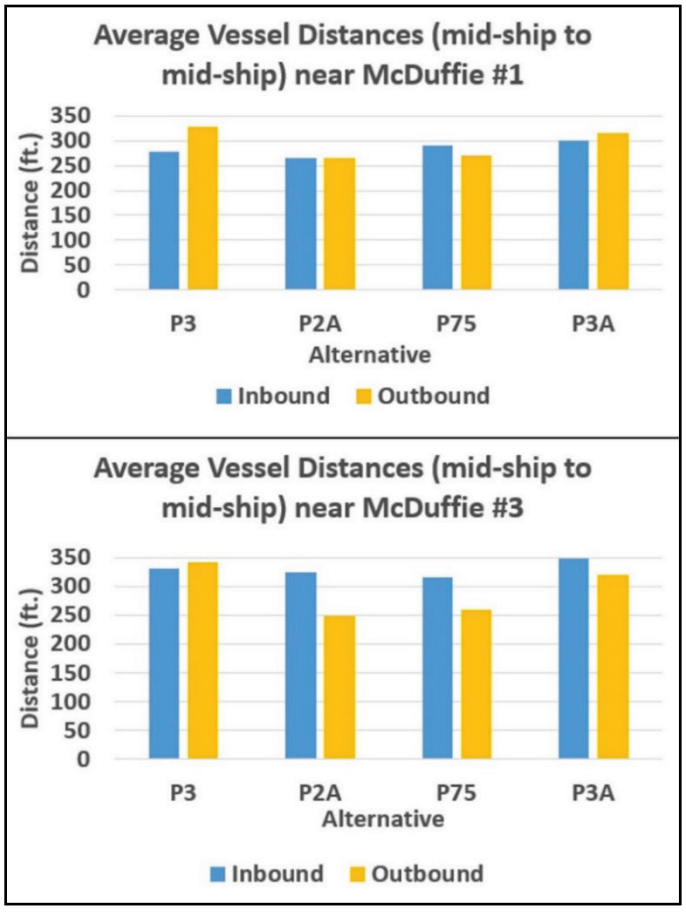


Figure 53 presents the average vessel speed near McDuffie #1 (*top image*) and McDuffie #3 (*bottom image*). In these figures, vessel speed generally decreases across the alternatives (P3, P2A, P75, and P3A) near McDuffie #1 and McDuffie #3. Average vessel speed for P3 simulations were approximately 1.5 kn greater than average vessel speed for P3A (Table 12).

Figure 53. Average vessel speeds near McDuffie #1 and McDuffie #3 across the alternatives.

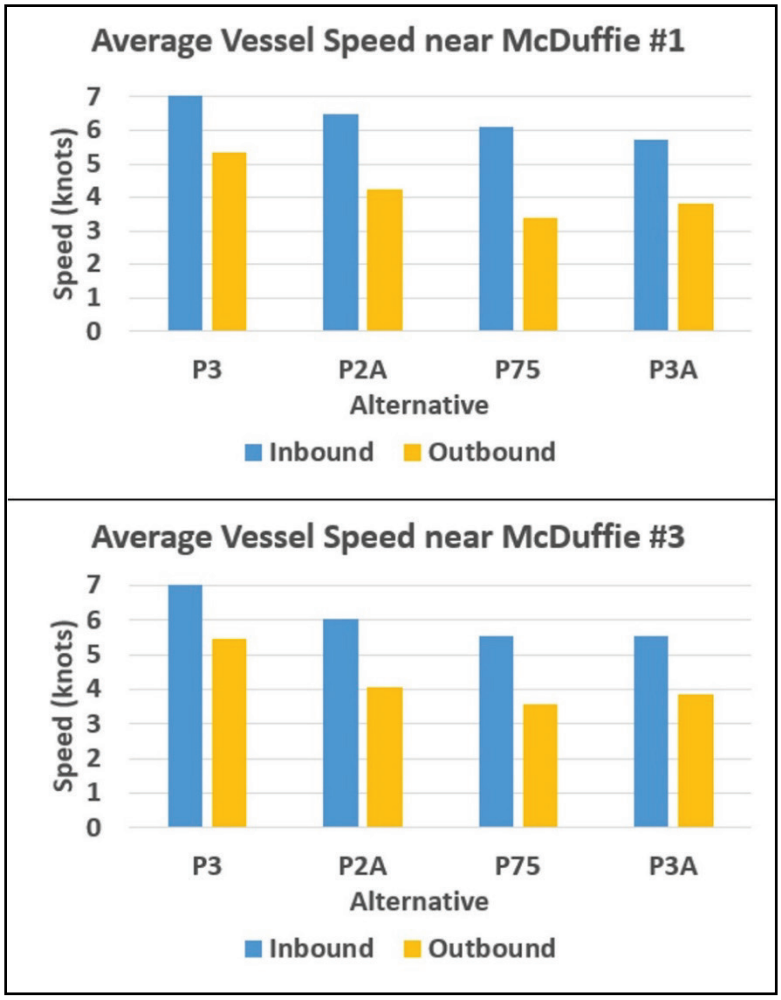


Table 12. Comparison of vessel speed near McDuffie #1 and #3 for P3 and P3A.

Alternative	Heading	Average Speed near McDuffie #1 (kn)	Average Speed near McDuffie #3 (kn)
P3	Inbound	7.1	7.1
P3A	Inbound	5.7	5.6
P3	Outbound	5.4	5.5
P3A	Outbound	3.8	3.9
Difference between Inbound P3 and P3A speeds		1.4	1.6
Difference between Outbound P3 and P3A speeds		1.5	1.6

8 Final Recommendations

Overall conclusions and recommendations are based on track plots (Appendix A), informational sheets with pilot comments (Appendix A), final pilot questionnaires (Appendix B), analysis of the results (Section 7), discussions after each simulation, and the final wrap-up meetings completed at the end of each testing week.

P3A is the recommended channel design from the alternatives tested. P3A featured the highest success rates (Figure 43) and the greatest recommendations from the final pilot questionnaires (Appendix B). P3A also featured considerable midship-to-midship distances between the transiting vessel and the docked vessels at McDuffie #1 and McDuffie #3 (Figure 52) and minimal surge and sway movement of the docked vessels (Figure 50 and Figure 51).

The other alternatives tested (P3, P2A, P75) featured low success rates (42% or less) and are considered to have inadequate spacing (P2A and P75) or too small of a channel expansion transition (P3). While P3 featured a 100 ft expansion in the navigation channel, the smaller transition forced the pilots to use a more aggressive maneuver (higher speeds) than in P3A (Table 12). P3, P2A, and P75 are all not recommended as those simulations featured excessive vessel interaction with the transiting vessel and the docked vessels at the McDuffie Coal Terminal.

While the P3A channel was able to reduce the transiting-vessel and docked-vessel interaction, it did not eliminate it entirely. Therefore, speed will still be an important factor in limiting the interaction. It is expected that pilot rules regarding speed restrictions in this area will still be required.

References

Fenical, S. W. 2015. *Technical Report Ship Hydrodynamics and Mooring Analysis Berth 6 Bulkhead Extension Port of Port Arthur, TX*. Technical Report. Austin, TX: Coast and Harbor Engineering. https://portpa.com/docs/Foley-Ditch-Outfall/Ship%20Hydrodynamics,%20Mooring%20Analysis%20Tech%20Rpt.pdf.

Intertanko. 2019. "Guidance on Mooring System Management Plans (MSMP)." https://www.irclass.org/media/3984/intertanko-guidance-on-mooring-system-management-plans-msmp-mooring_.pdf.

Johnston, M., and E. Godsey. 2021. "Multifaceted Approach of Assessing Channel Design through Ship Simulations in Mobile Harbor, AL." *Journal of Waterway, Port, Coastal, and Ocean Engineering* 147(5). https://doi.org/10.1061/(ASCE)WW.1943-5460.0000656.

Johnston, M. M., S. C. Kim, and M. C. Allison. 2021. *Mobile Harbor, Alabama Navigation Study: Ship Simulation Report*. ERDC/CHL TR-21-17. Vicksburg, MS: US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory. https://hdl.handle.net/11681/42300.

Luettich, R. A., and J. J. Westerink. 2004. *Formulation and Numerical Implementation of the 2D/3D ADCIRC Finite Element Model Version 44.XX*. https://adcirc.org/wp-content/uploads/sites/2255/2018/11/adcirc_theory_2004_12_08.pdf.

USACE SAM (US Army Corps of Engineers, Mobile District). 2019. *Mobile Harbor, Mobile, Alabama Integrated Final General Evaluation Report with Supplemental Environmental Impact Statement, Mobile County, Alabama (GRR/SEIS)*. Mobile, AL: US Army Corps of Engineers, Mobile District. https://www.sam.usace.army.mil/Portals/46/docs/program_management/MHGRR/1-Mobile%20Harbor%20Main%20Report.pdf.

Appendix A: Track Plots, Informational Sheets, and Graphs

The following 85 pages present track plots, informational sheets, and graphs.

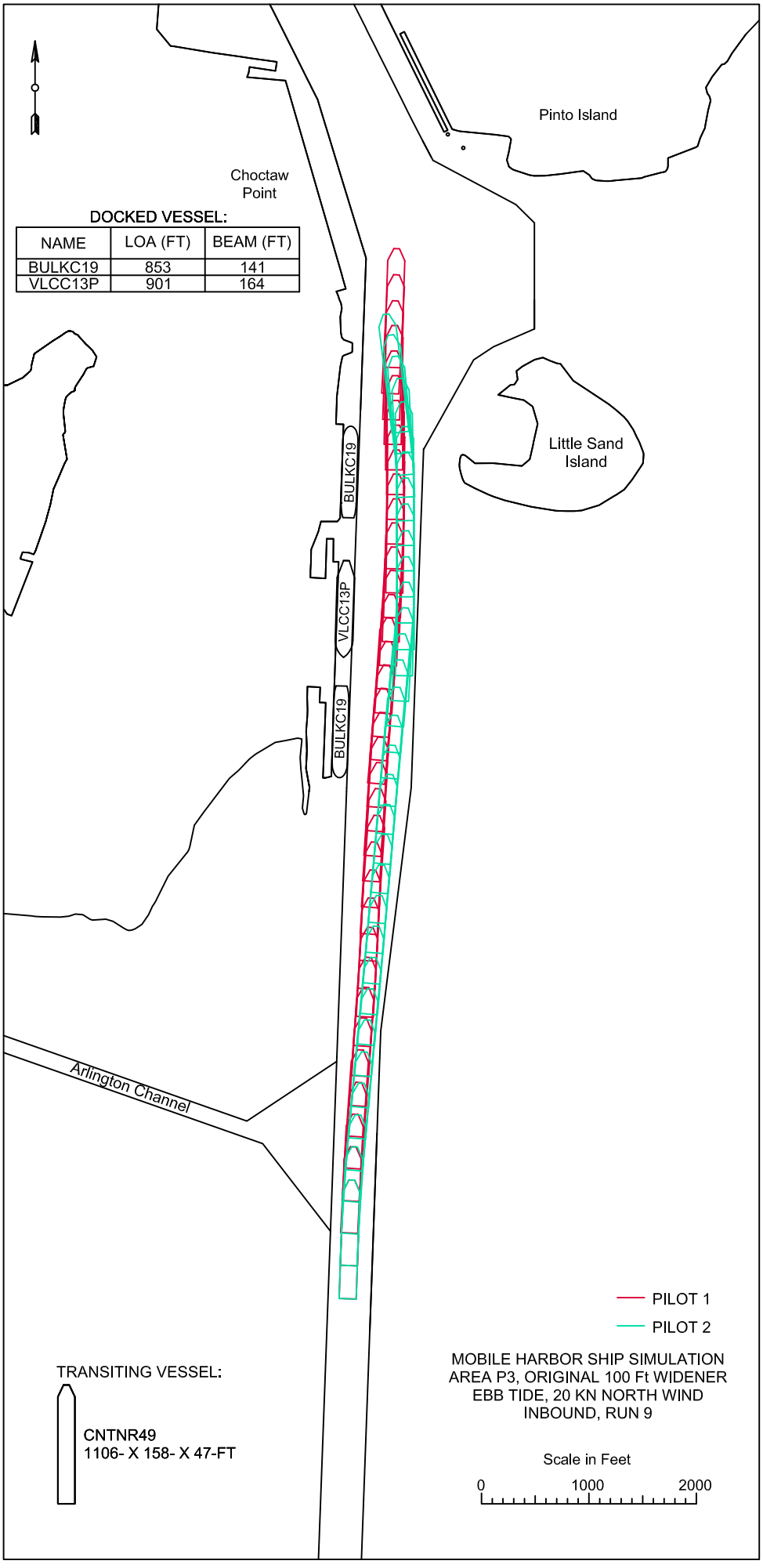

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 1
PILOT 2
MOBILE HARBOR SHIP SIMULATION
AREA P3, ORIGINAL 100 Ft WIDENER
EBB TIDE, 20 KN NORTH WIND
INBOUND, RUN 9
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 1

Informational Sheet Plate 1

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
9	P3	Inbound	Ebb	20 knots N	Zero Bank Effect

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
1	Conditions allowed for reasonable maneuvering and manageable speed while passing loaded ships. Due to the lengthening of the inbound containership, the start of the widener requires aggressive maneuvering in order to take advantage of the extra room, as the inbound ship's stern will creep west of the centerline in close proximity to a loaded ship at McDuffie #1. The widener beginning further to the south would allow a larger ship to move over sooner and take advantage of the room more efficiently.	An additional 1.5m of water was added to this simulation	-	-
2	Was able to guide vessel into widener but had a little difficulty "shaping up" or getting parallel with McDuffie #1. Would like widener to start further south to avoid this issue.		2	2

McDuffie Information:

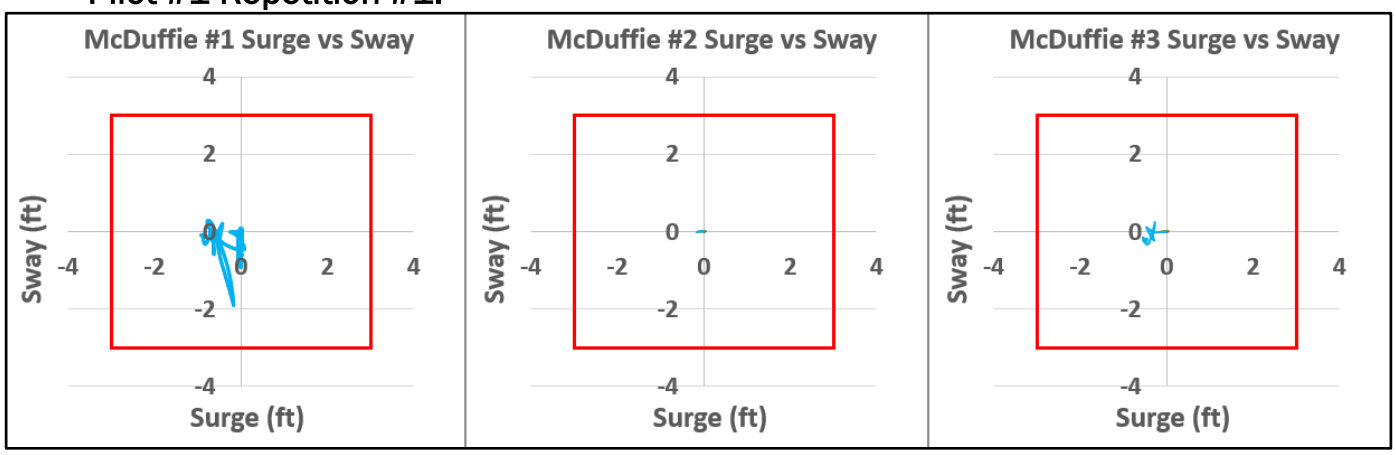
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
1	220	6.4	-0.9	-1.9	216	6.7	-0.2	0.0	257	6.7	-0.6	-0.3
2	338	7.0	-3.5	-6.0	390	7.1	-0.3	0.0	365	6.6	-0.3	0.4

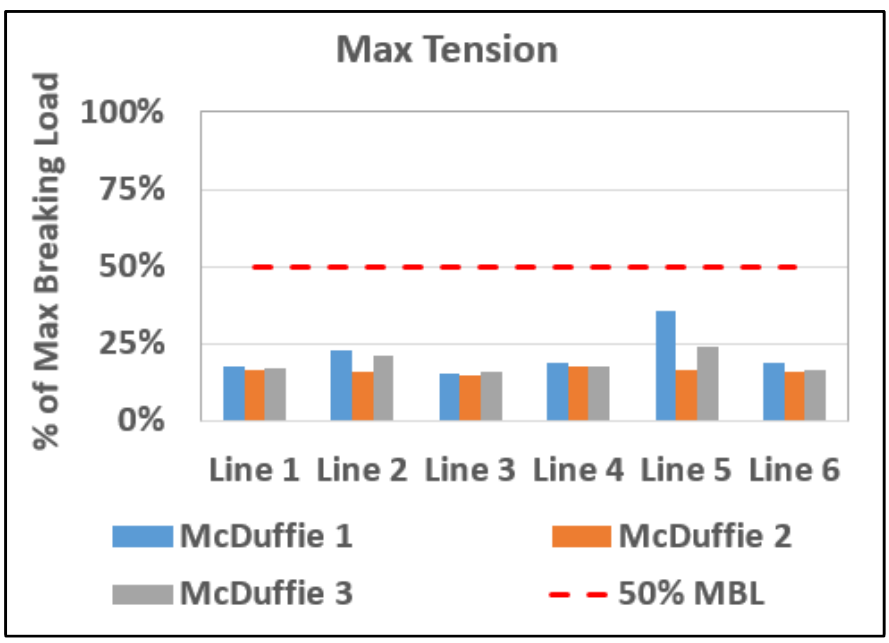
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
1	NO	NO	N/A
2	NO	YES	McDuffie #1

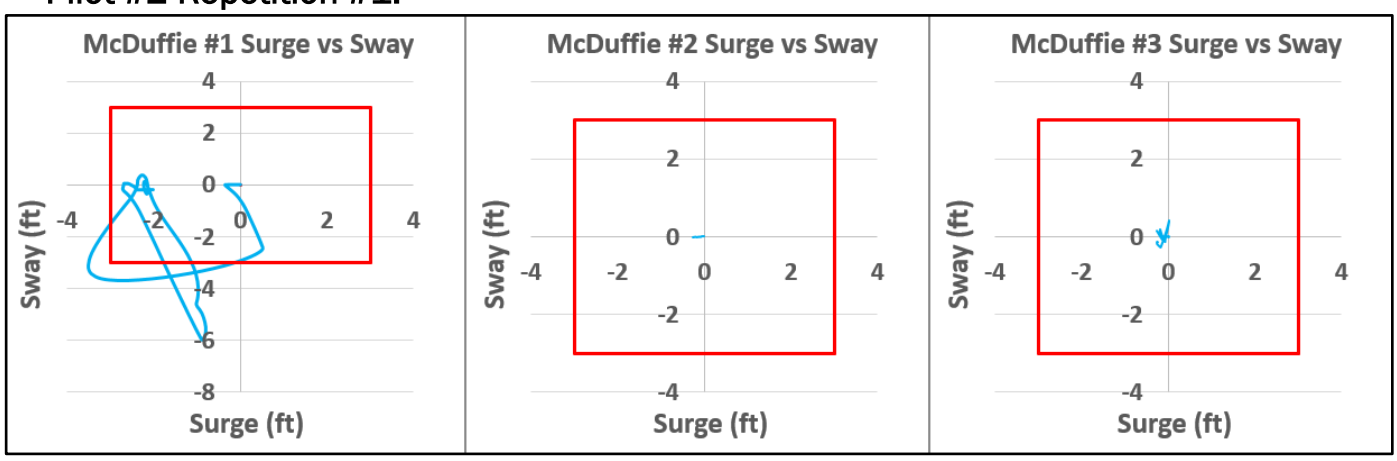
Informational Graphs Plate 1

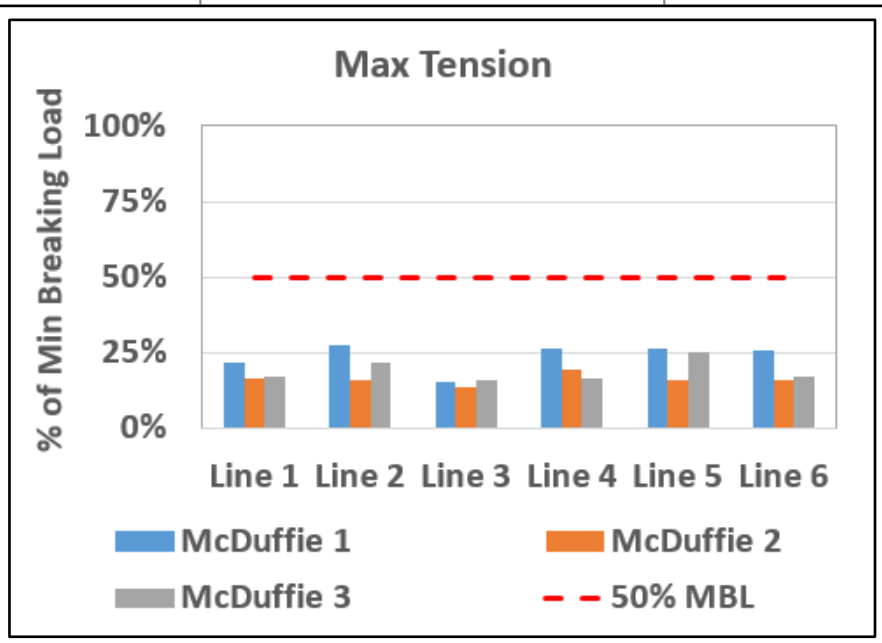
Pilot #1 Repetition #1:





Pilot #2 Repetition #1:





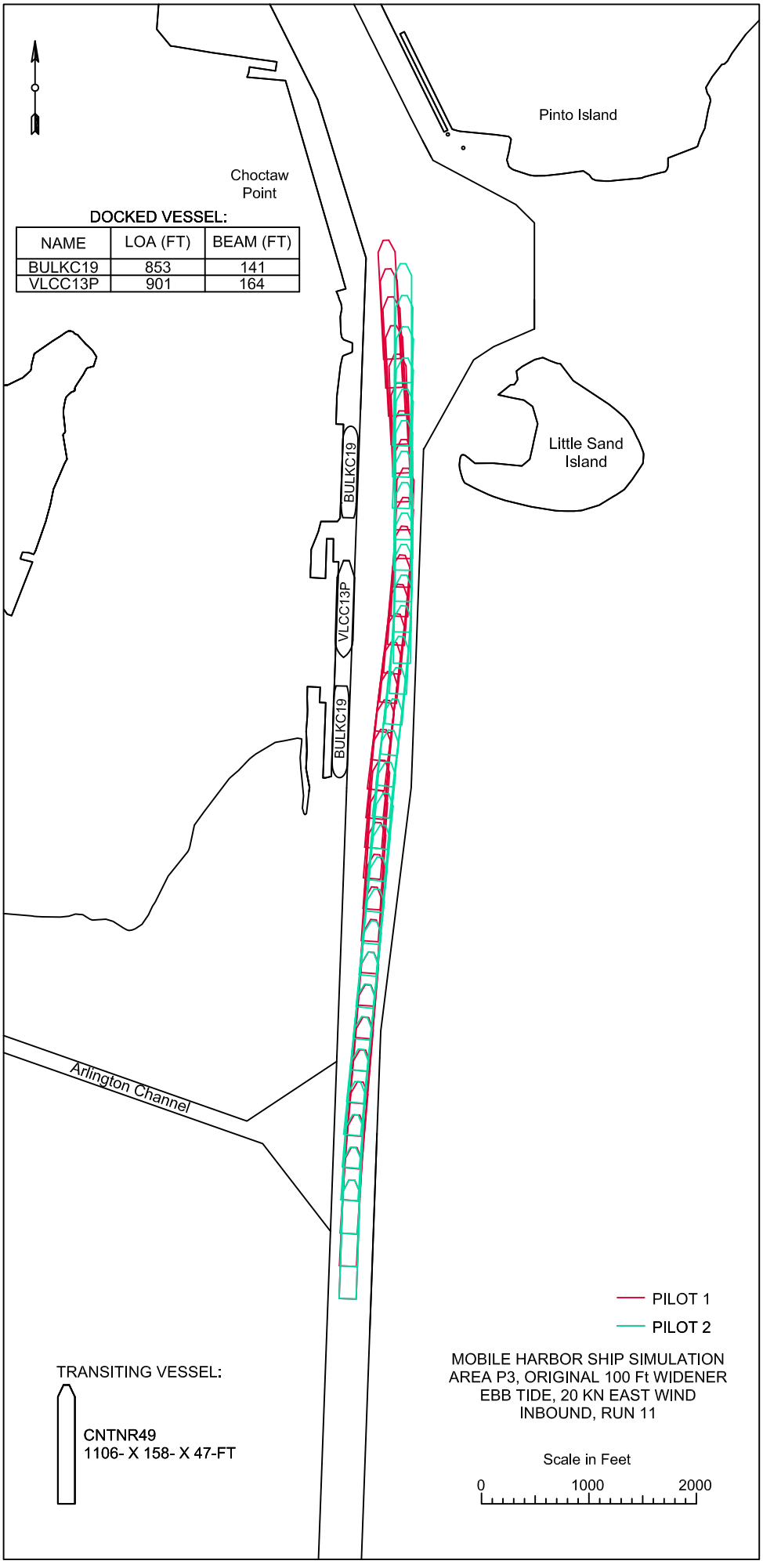

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 1
PILOT 2
MOBILE HARBOR SHIP SIMULATION
AREA P3, ORIGINAL 100 Ft WIDENER
EBB TIDE, 20 KN EAST WIND
INBOUND, RUN 11
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 2

Informational Sheet Plate 2

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
11	P3	Inbound	Ebb	20 knots E	Zero Bank Effect

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
1	Ebb conditions realistic. In attempt to get ship far to the E in order to use the widener, had to increase RPMs and use max rudder to steady ship up without running aground. Essentially, the only way to take advantage of the extra room with a large ship requires very aggressive action at a very critical location (proximity to McDuffie#1).		2	3
2	Took full advantage of channel being widened. Did not seem to have as much ship-to-ship interaction. Would recommend to widener start further south so that the inbound maneuvering vessel can get into the widener earlier before approaching McDuffie #1.	No tension was set for Line 3 (FwdSpr) at the start of the run (McDuffie #1)	3	2

McDuffie Information:

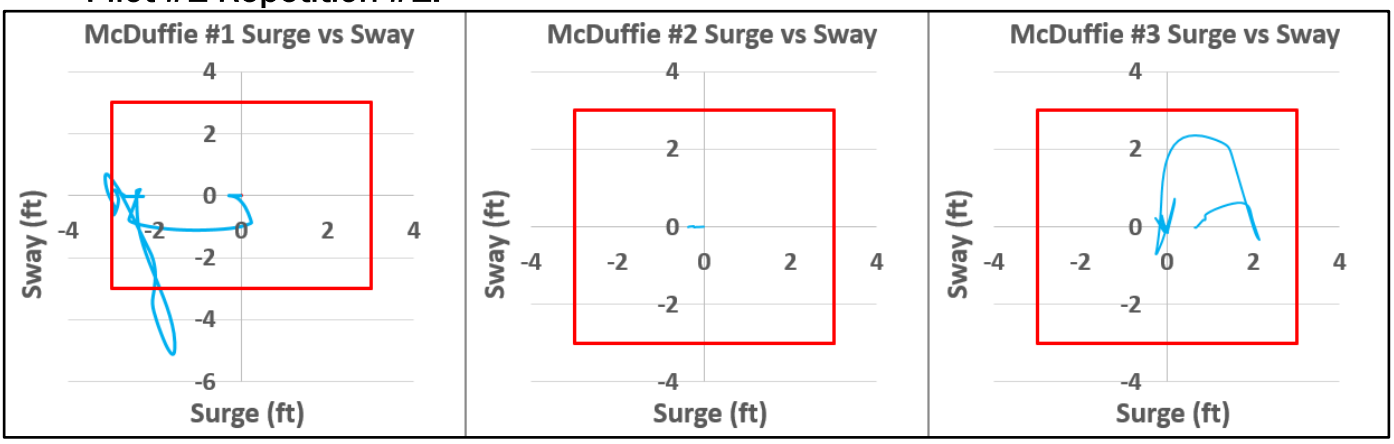
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
1	240	7.3	-3.2	-5.1	295	7.4	-0.4	0.0	345	7.2	2.2	2.4
2	309	7.6	-2.2	-6.5	350	7.6	-0.2	0.0	356	7.7	-0.6	-0.4

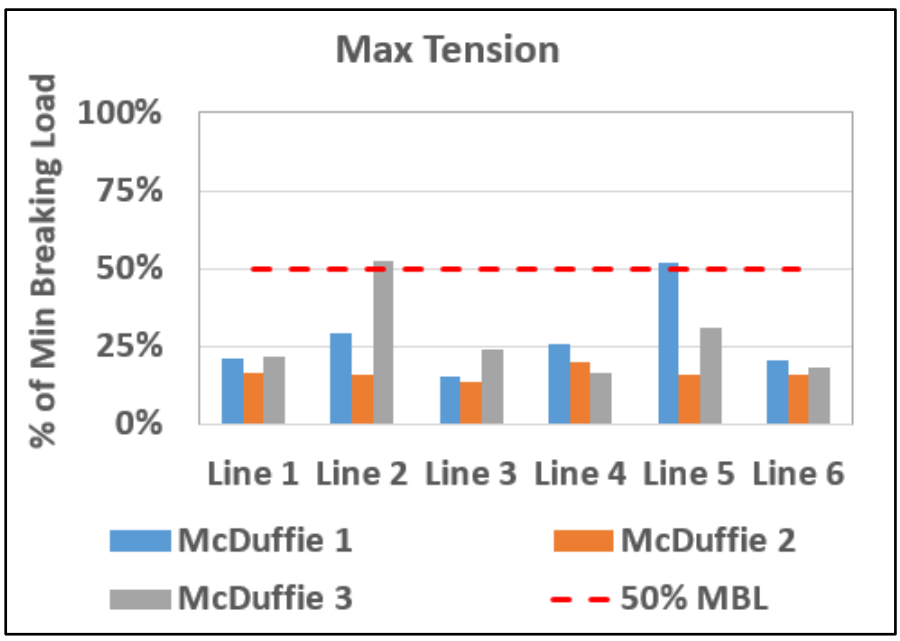
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
1	YES	YES	McDuffie #1 & #3
2	NO	YES	McDuffie #1

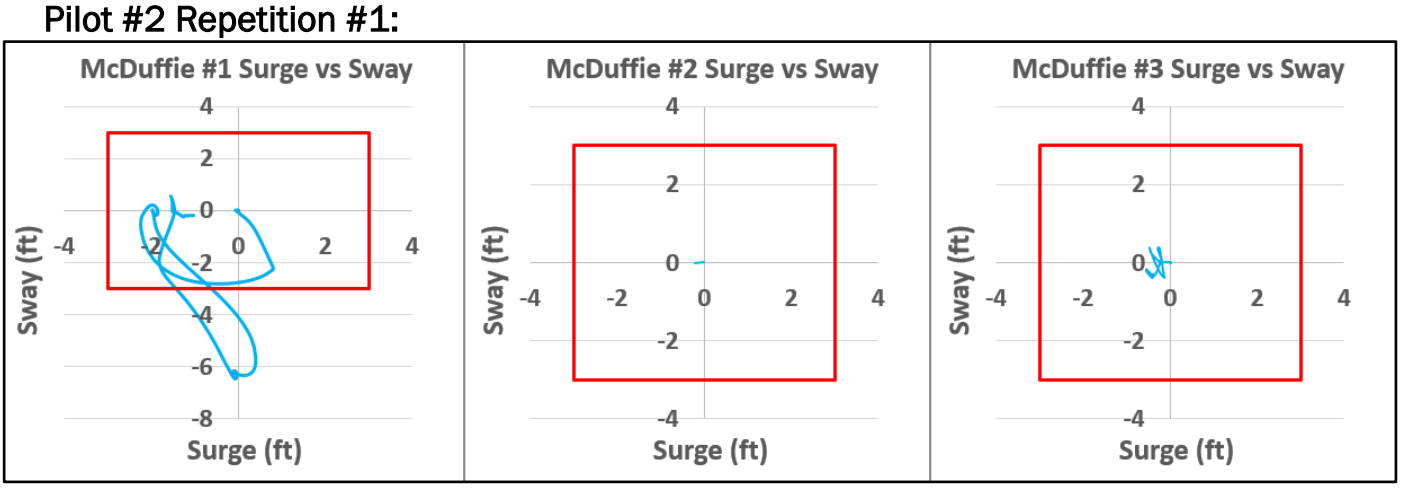
Informational Graphs Plate 2

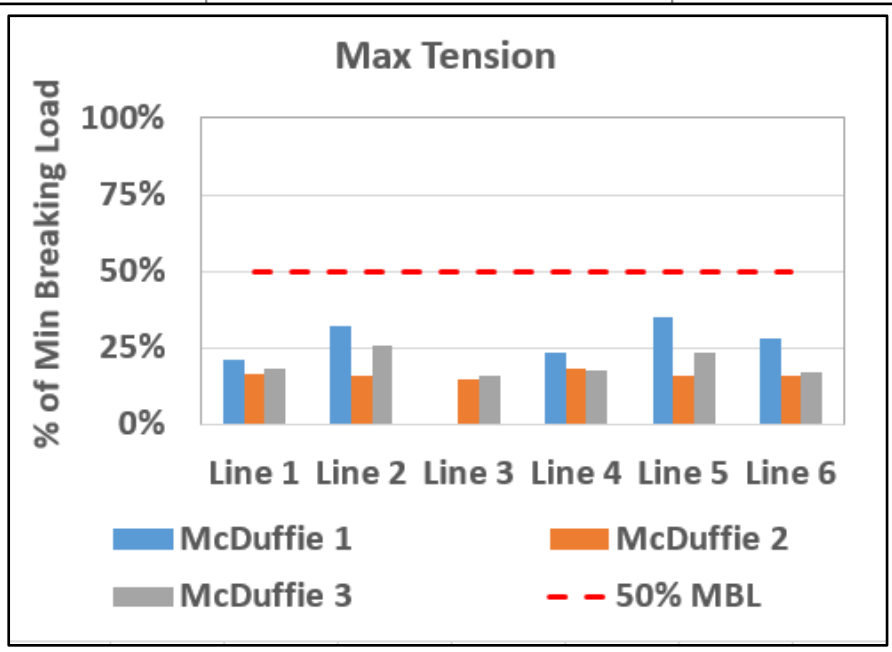
Pilot #1 Repetition #1:





Pilot #2 Repetition #1:





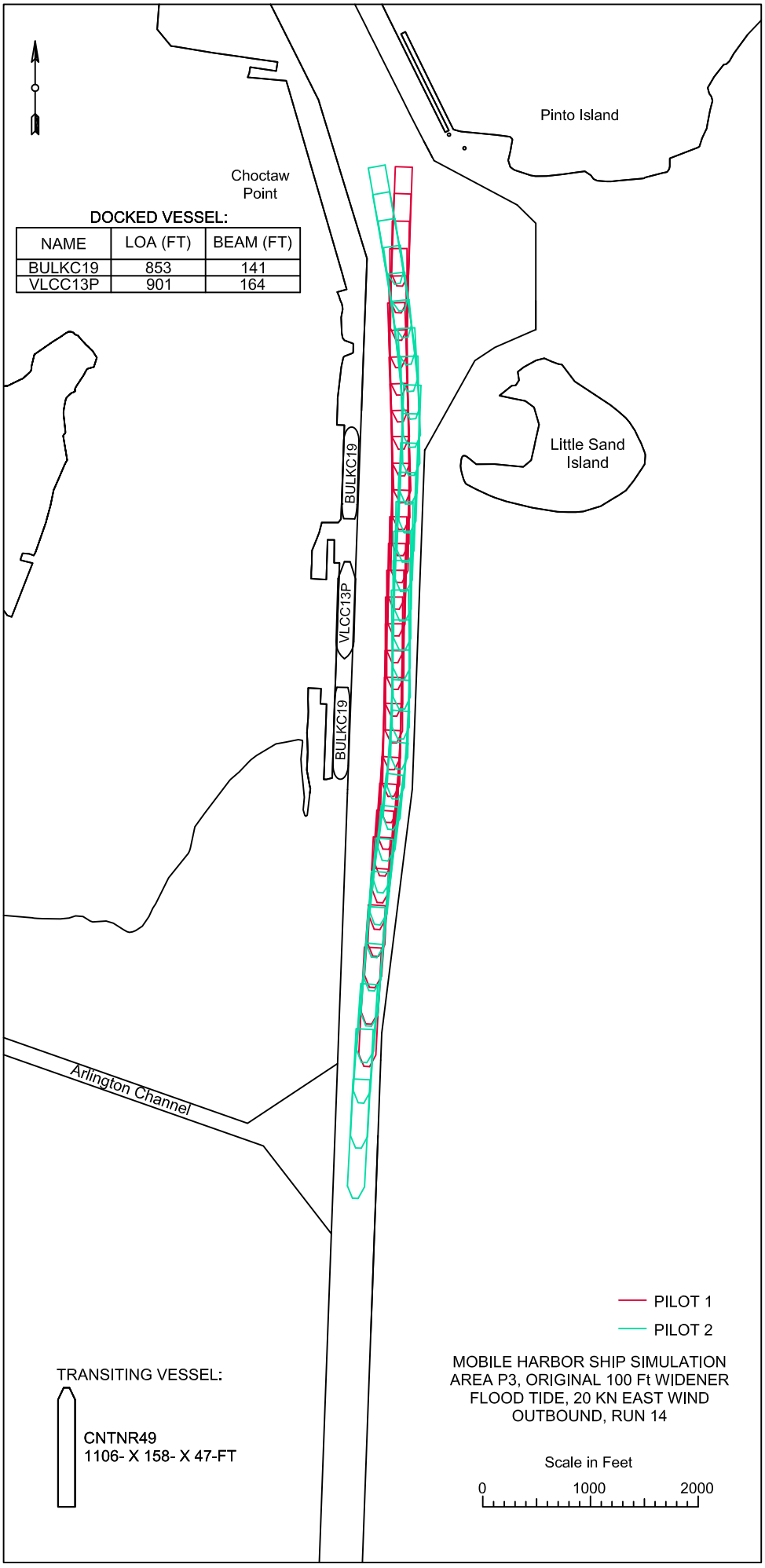

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 1
PILOT 2
MOBILE HARBOR SHIP SIMULATION
AREA P3, ORIGINAL 100 Ft WIDENER
FLOOD TIDE, 20 KN EAST WIND
OUTBOUND, RUN 14
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 3

Informational Sheet Plate 3

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
14	P3	Outbound	Flood	20 knots E	Zero Bank Effect

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
1	Good run, realistic conditions. Widener providing necessary room for these size ships.	Wind was set to SE for first 4:45 then swapped to E	-	-
2	Started off in a turn and was able to use extended widener to recover from turn and pass McDuffie without excessive speed.		2	1

McDuffie Information:

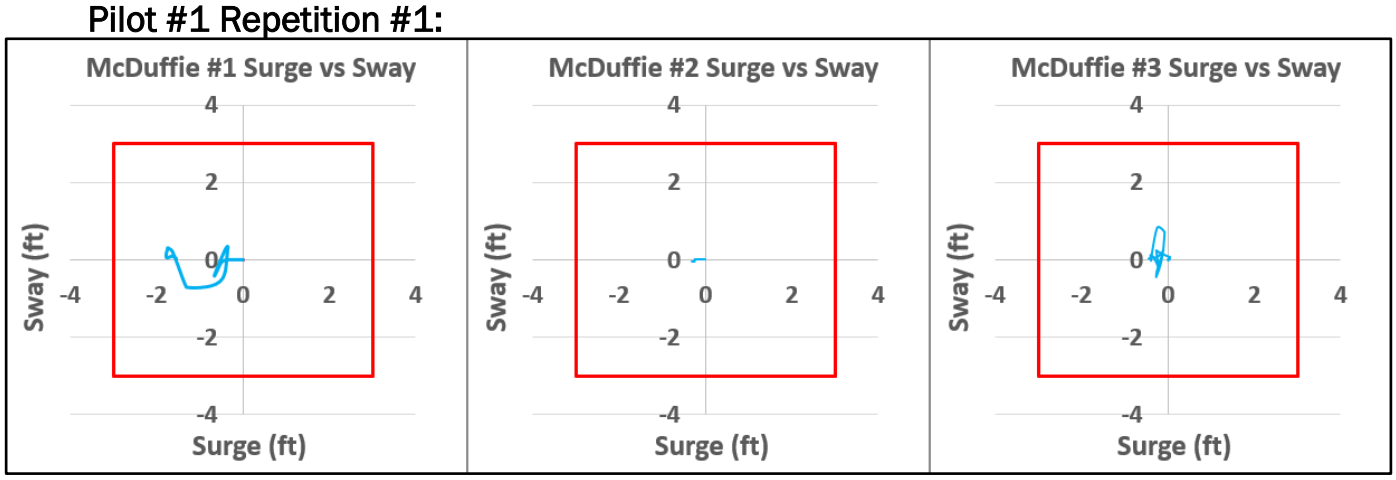
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
1	318	4.9	-1.8	-0.7	295	4.9	-0.3	0.0	321	5.2	-0.4	0.9
2	383	5.8	-3.3	-6.7	356	5.6	-0.5	-0.1	400	5.7	0.3	0.9

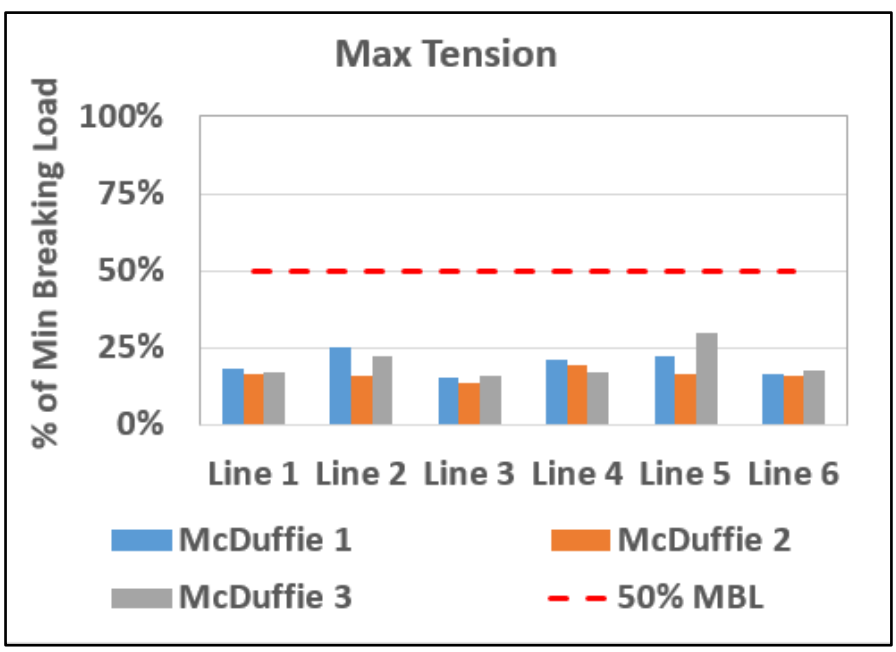
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
1	NO	NO	N/A
2	NO	YES	McDuffie #1

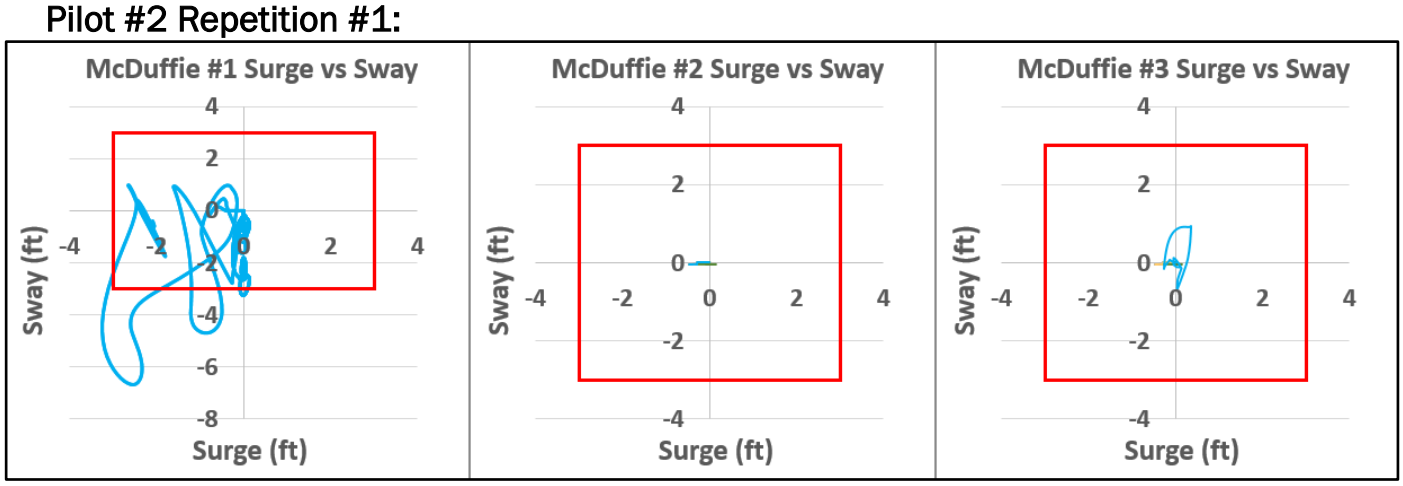
Informational Graphs Plate 3

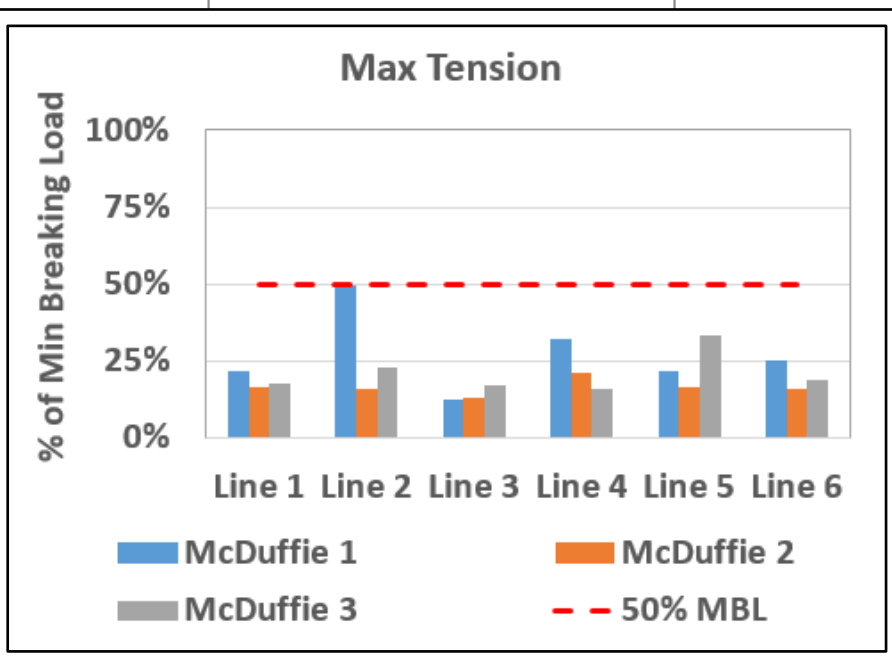
Pilot #1 Repetition #1:





Pilot #2 Repetition #1:





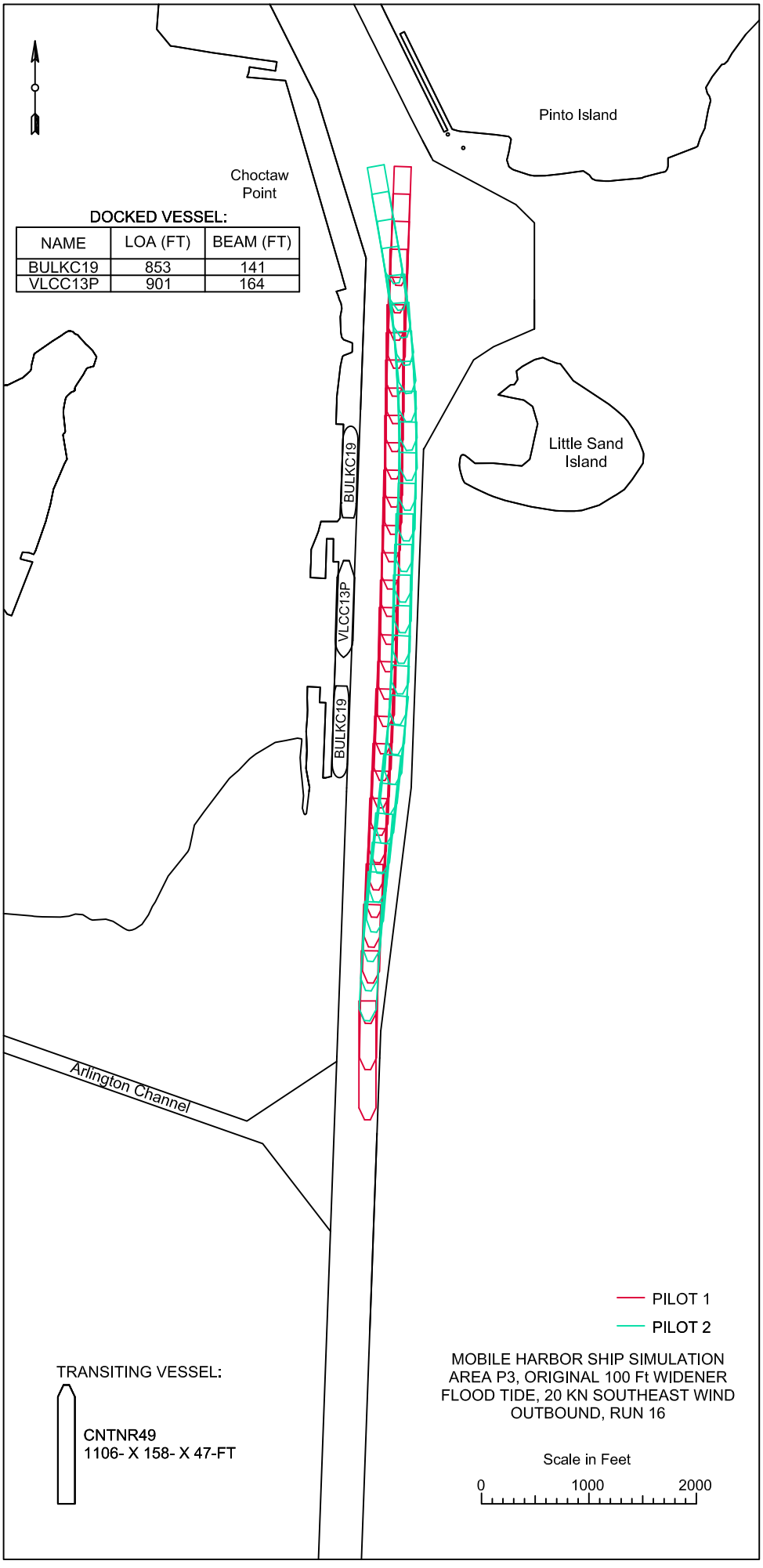

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 1
PILOT 2
MOBILE HARBOR SHIP SIMULATION
AREA P3, ORIGINAL 100 Ft WIDENER
FLOOD TIDE, 20 KN SOUTHEAST WIND
OUTBOUND, RUN 16
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 4

Informational Sheet Plate 4

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
16	P3	Outbound	Flood	20 knots SE	Zero Bank Effect

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
1	Good run in realistic conditions. Did not use entire widener but extra room will be necessary with ships this large.		-	-
2	Very similar to previous exercise with east wind. Was able to use extended widener. Because taper ends just south of McDuffie #1, I had to maneuver closer to McDuffie #1 than I would have liked.		2	2

McDuffie Information:

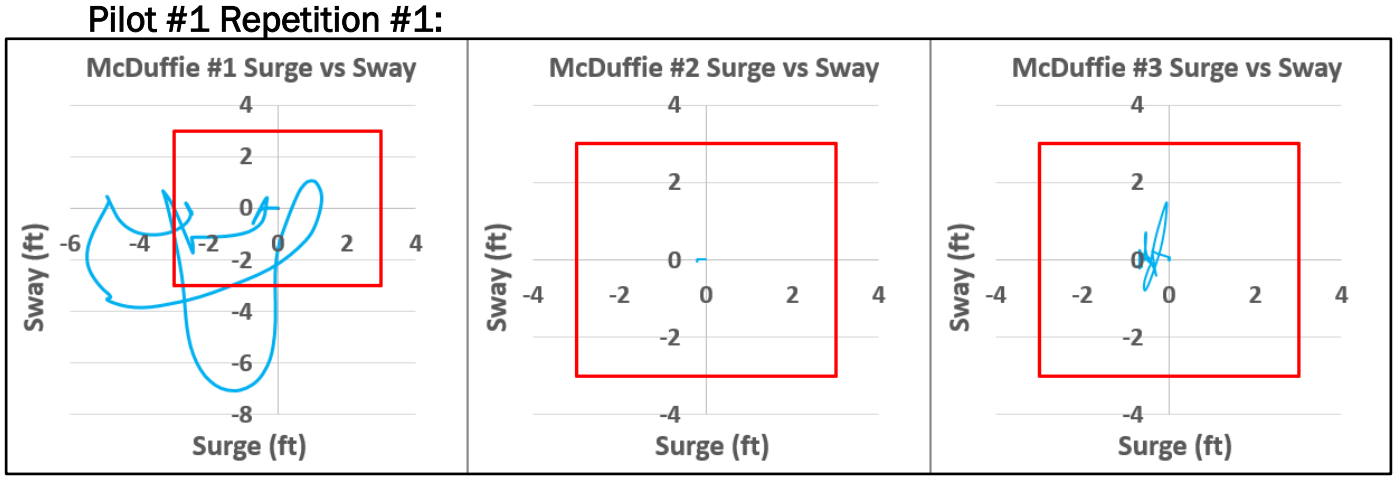
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
1	250	5.1	-5.2	-6.0	238	5.1	0.0	0.0	257	5.1	-0.6	-1.6
2	362	5.6	-2.4	-6.4	365	5.7	-0.2	0.0	391	5.8	-0.6	1.3

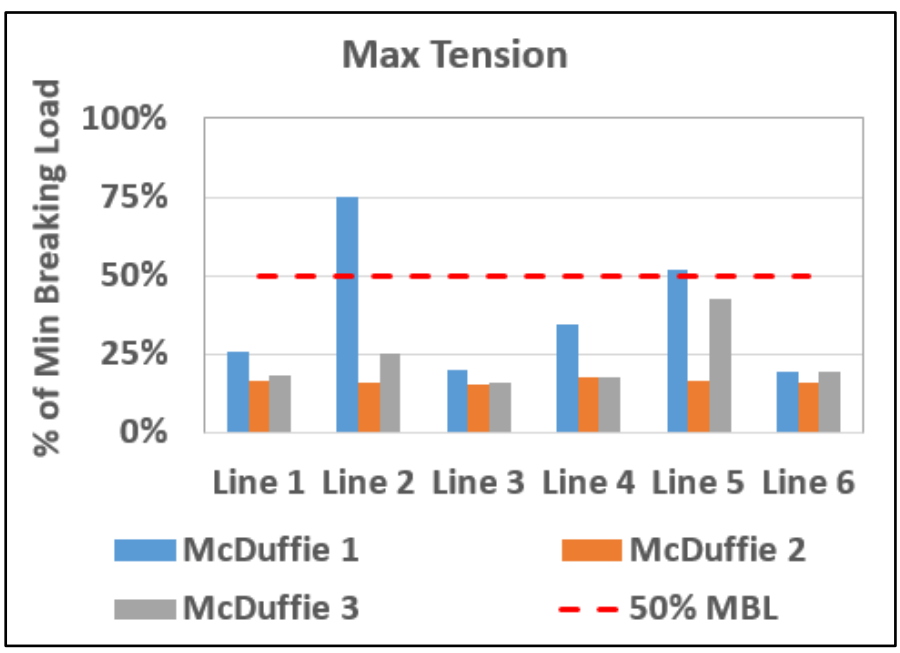
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
1	YES	YES	McDuffie #1
2	NO	YES	McDuffie #1

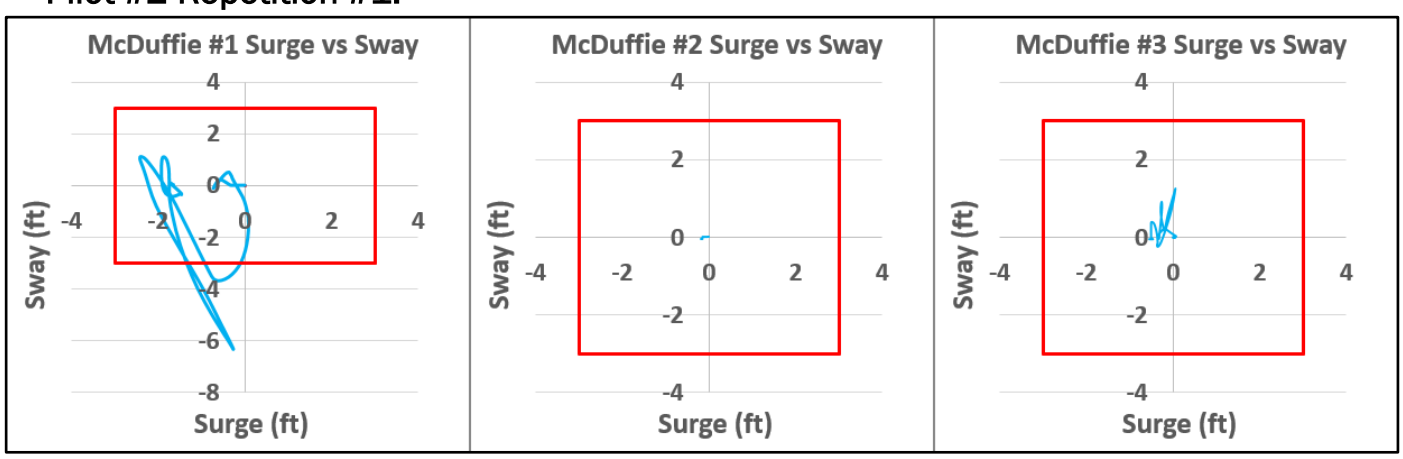
Informational Graphs Plate 4

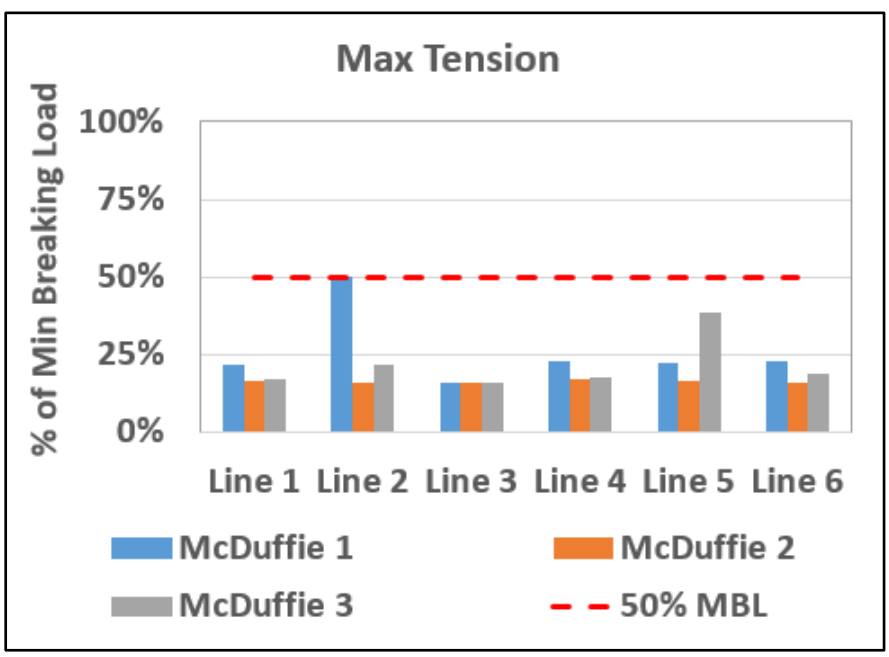
Pilot #1 Repetition #1:





Pilot #2 Repetition #1:





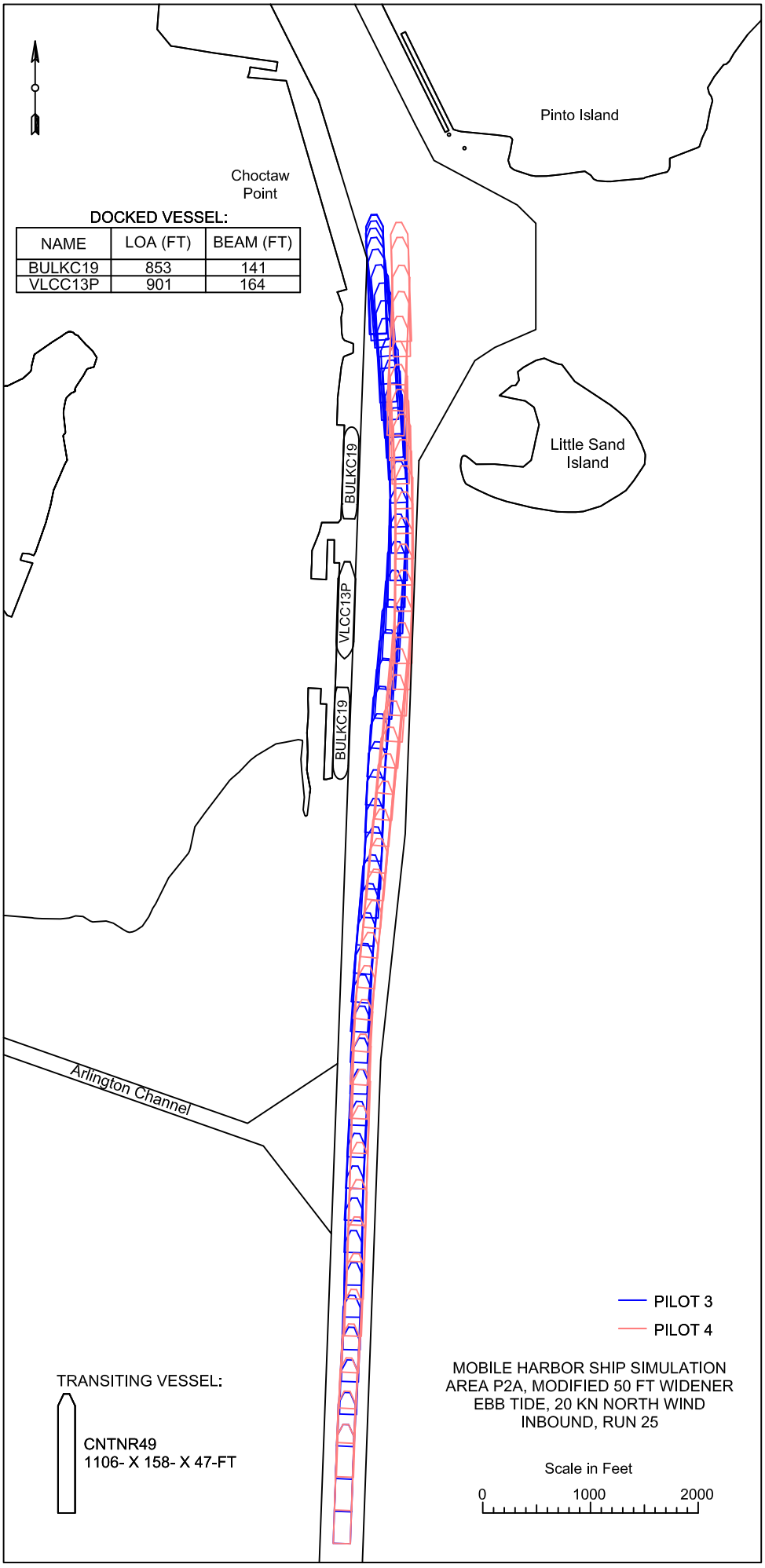

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
EBB TIDE, 20 KN NORTH WIND
INBOUND, RUN 25
Scale in Feet
0
1000
2000

Plate 5

Informational Sheet Plate 5

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
25	P2A	Inbound	Ebb	20 knots N	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Ship ran hard to the east, starting about halfway up McDuffie 1. I think too much speed (on my part). Still think this job is doable with lower speed/more tugs. The wider dredged east side didn't give these same results.		3	3
4	Felt little more shear to starboard when approaching McDuffie #1, but not too different than earlier exercises. Was able to control speed relatively easy with mild to moderate tug usage.		2	1

McDuffie Information:

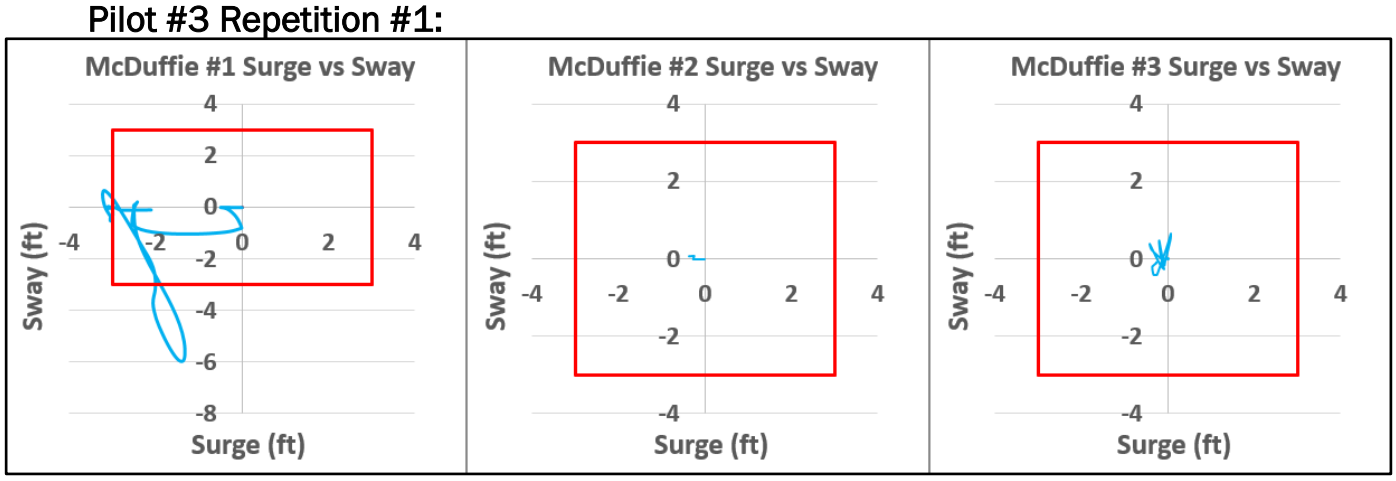
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	208	7.3	-3.2	-6.0	270	7.5	-0.4	0.1	296	6.9	-0.4	0.7
4	313	6.8	-0.5	-1.3	364	7	0.1	0.0	337	6.8	-0.5	-0.3

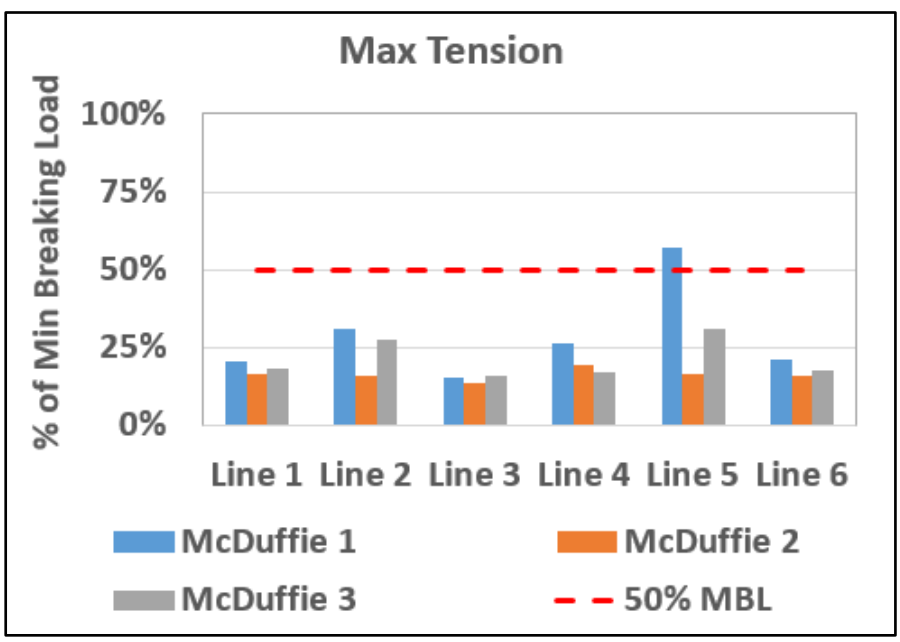
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	YES	YES	McDuffie #1
4	NO	NO	N/A

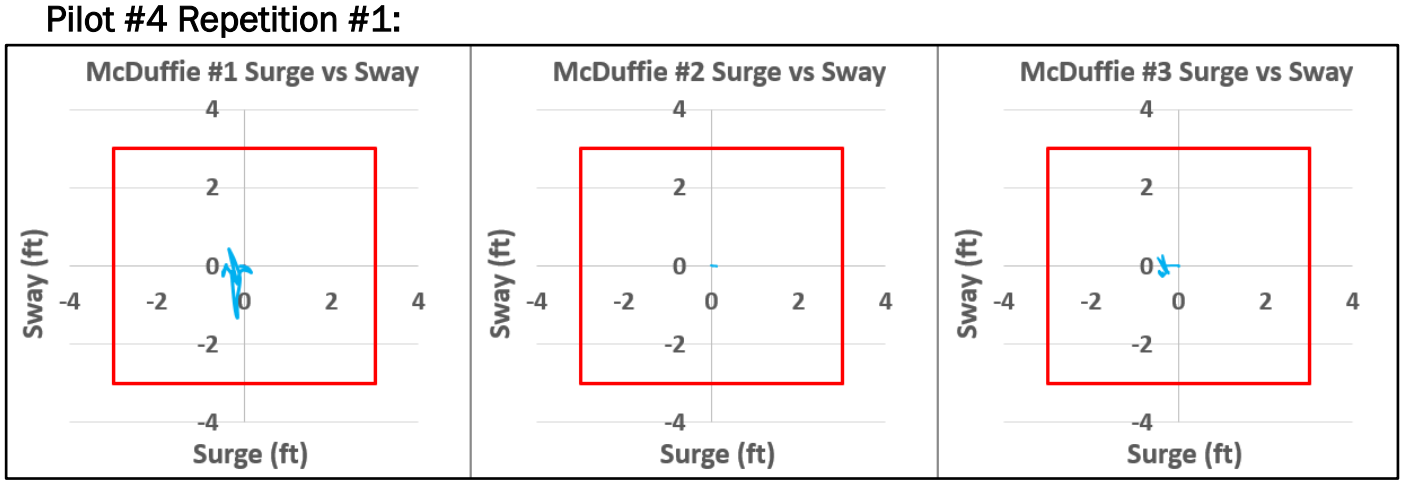
Informational Graphs Plate 5

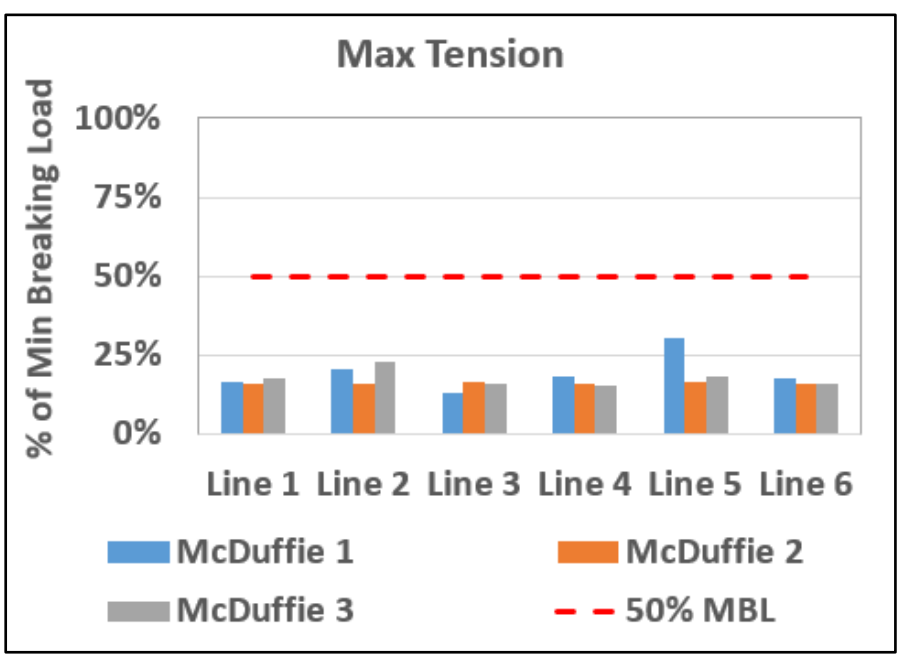
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





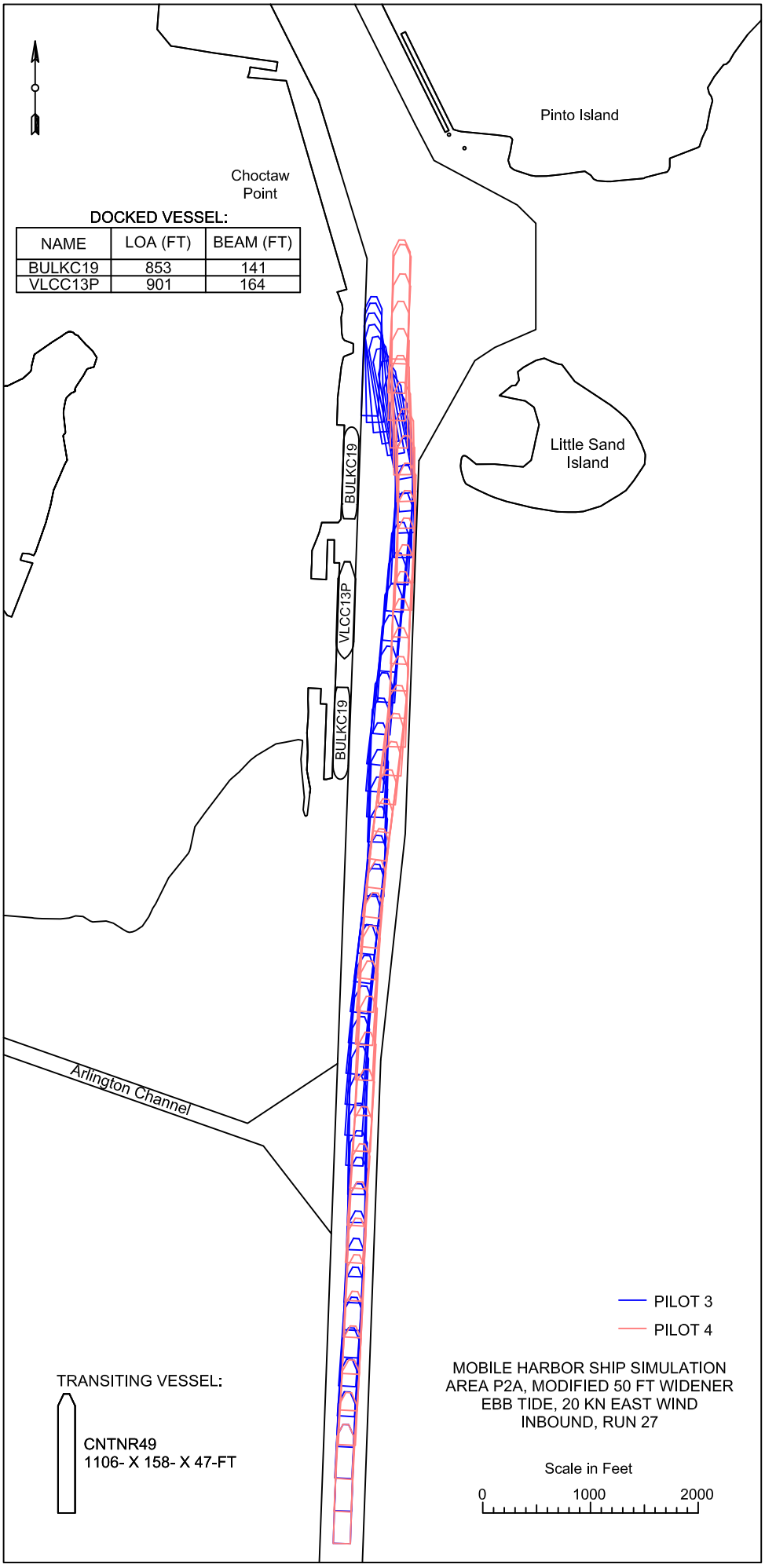

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
EBB TIDE, 20 KN EAST WIND
INBOUND, RUN 27
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 6

Informational Sheet Plate 6

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
27	P2A	Inbound	Ebb	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	On this run, the ship handled a bit differently when entering the wider section. It still ran to STBD, but not as quickly. This ship ran to the east off the lower end of little sand island. Not know why...the easterly dive was controllable and didn't go aground.	Pilot distracted by operator near end of run.	2	2
4	With the 20 kt east wind, I had to use a little more rudder and little more effort to get ship to east side of channel to pass ships. Was able to control ship's speed with moderate tug use. Had to use more bell on ship to check and steer ship from time to time.		2	2

McDuffie Information:

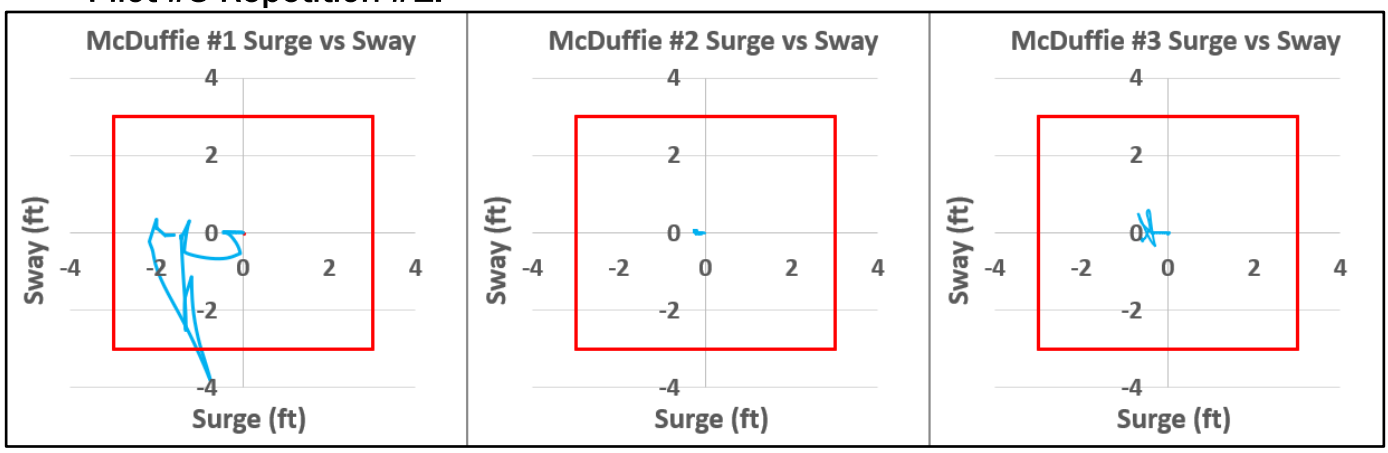
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	223	6.7	-2.2	-3.8	277	7.7	-0.3	0.1	358	6.1	-0.7	0.6
4	343	7.2	-0.5	-1.8	347	6.9	-0.4	0.0	360	7	-0.4	0.5

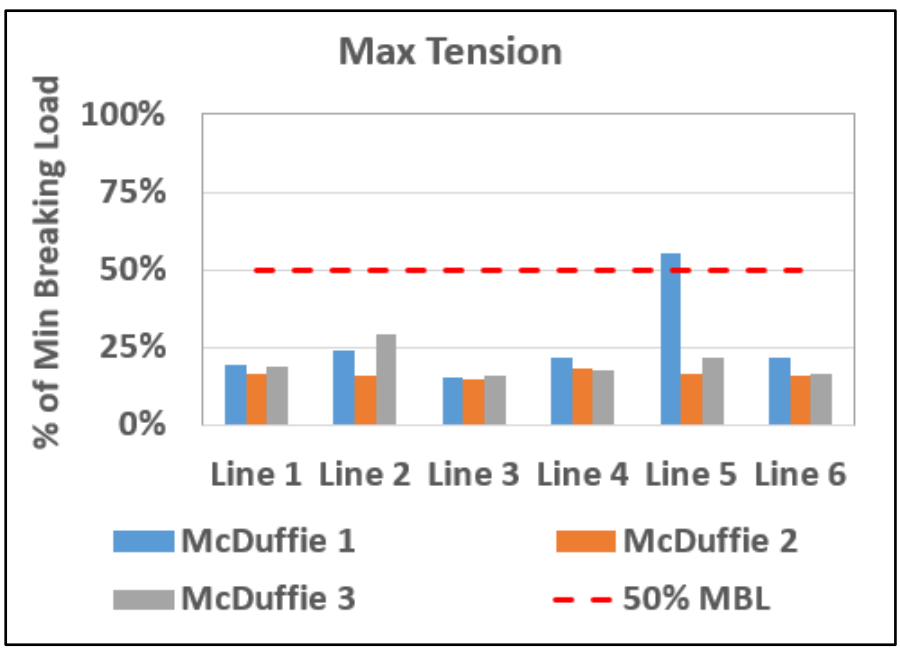
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	YES	YES	McDuffie #1
4	NO	NO	N/A

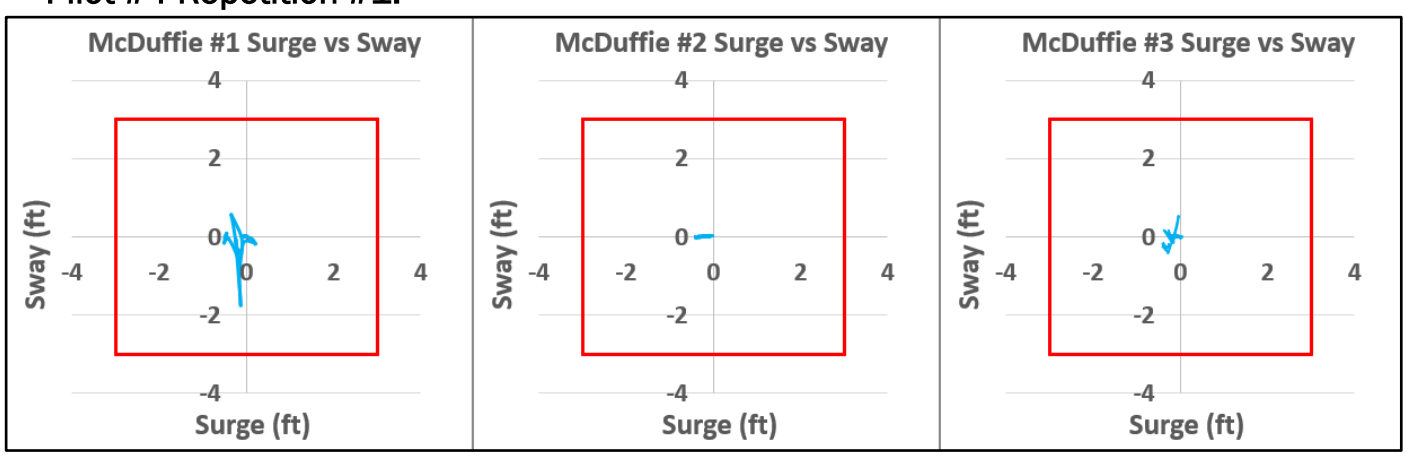
Informational Graphs Plate 6

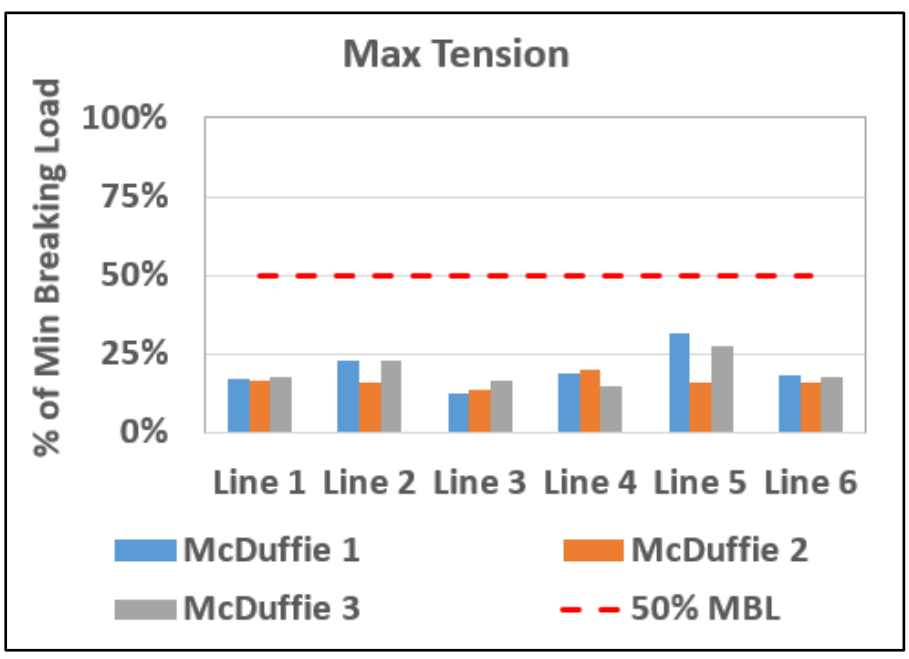
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





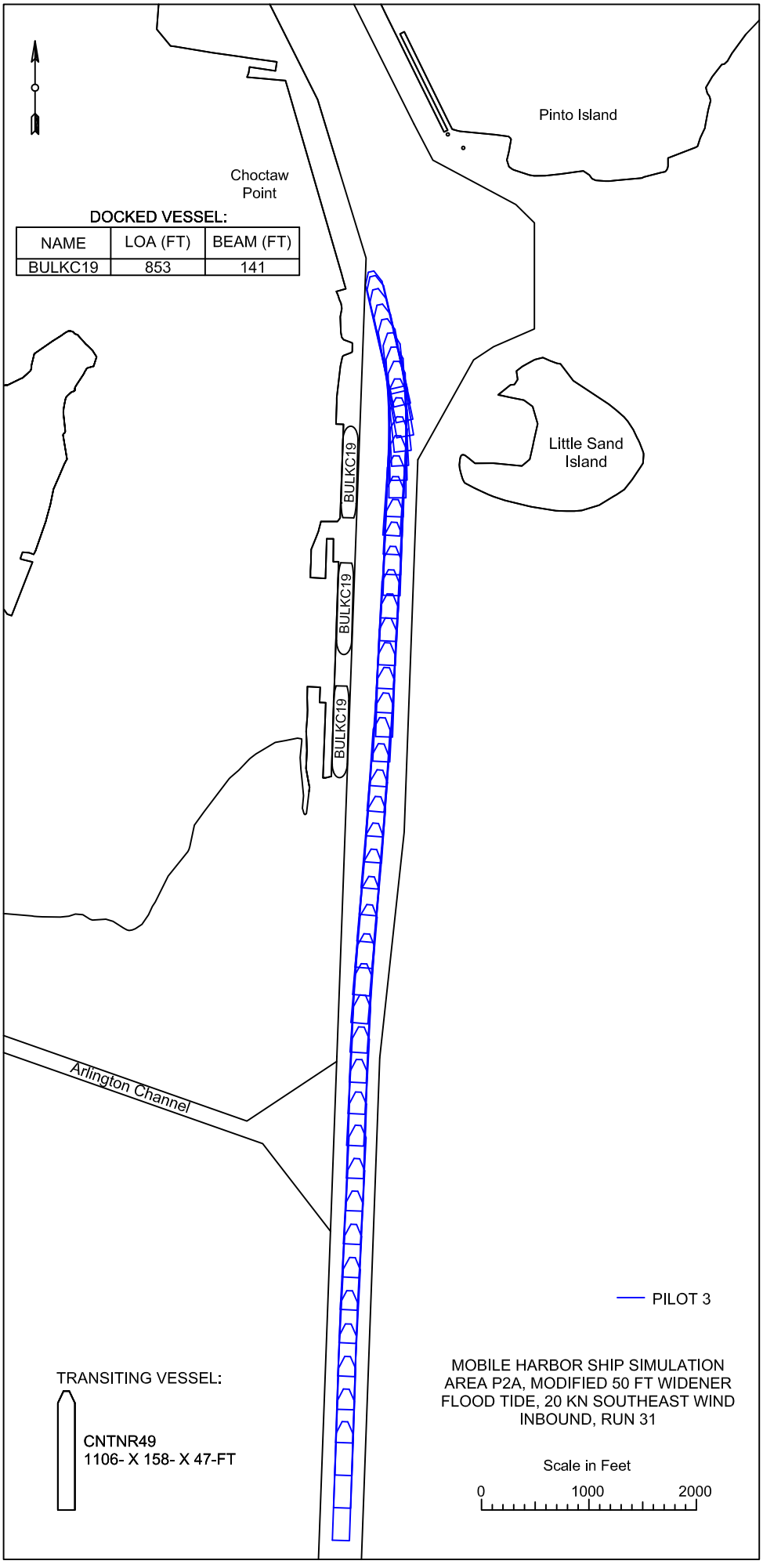

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
FLOOD TIDE, 20 KN SOUTHEAST WIND
INBOUND, RUN 31
Scale in Feet
0
1000
2000

Plate 7

Informational Sheet Plate 7

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
31	P2A	Inbound	Flood	20 knots SE	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	The flood tide makes slowing down in this area interesting. Still seem to be too close to McDuffie for a ship of this size.		2	2

McDuffie Information:

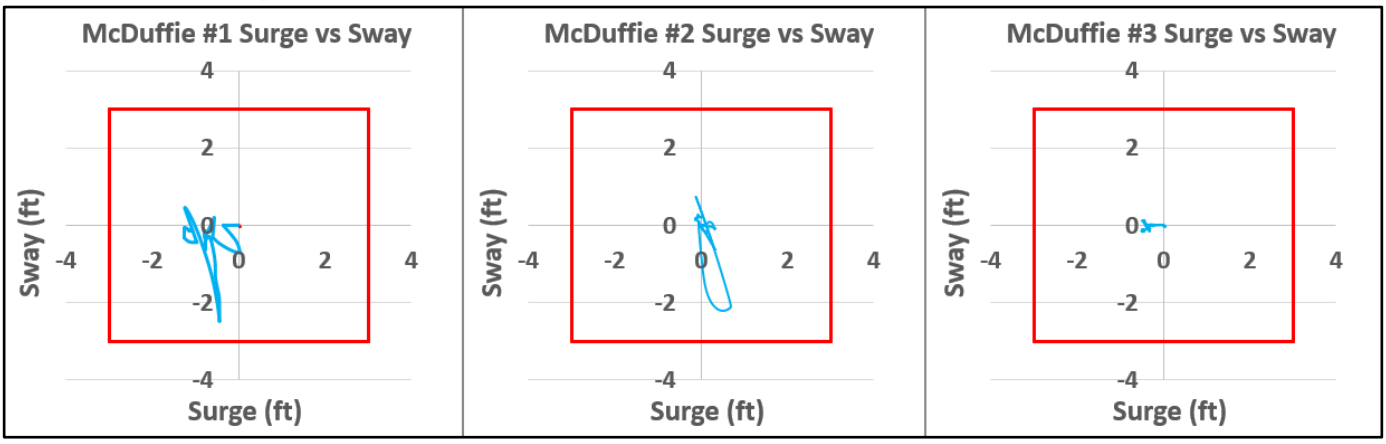
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	239	4.5	-1.3	-2.5	264	4.3	0.7	-2.2	279	3.4	-0.5	-0.2

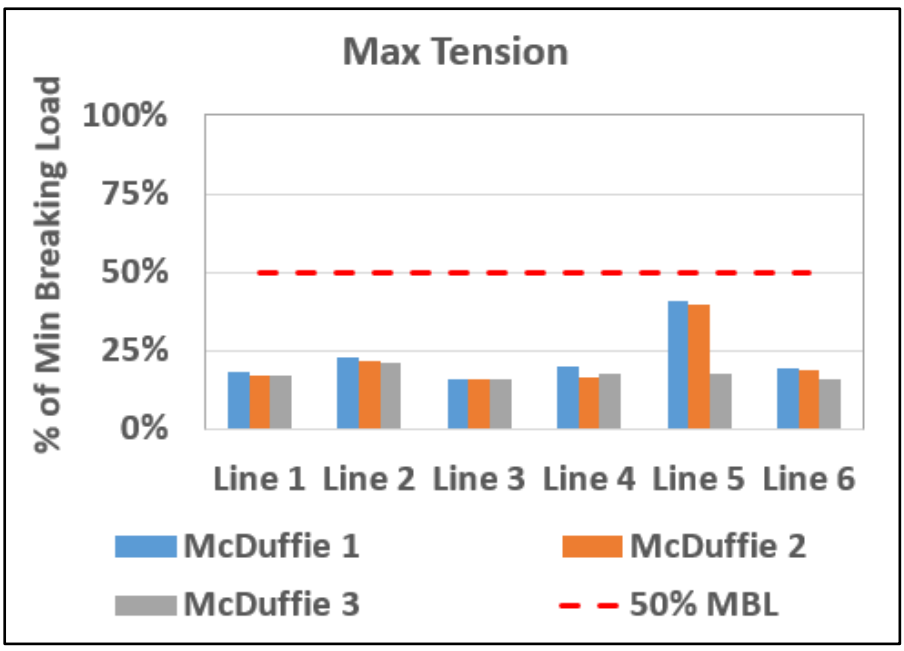
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A

Informational Graphs Plate 7

Pilot #3 Repetition #1:





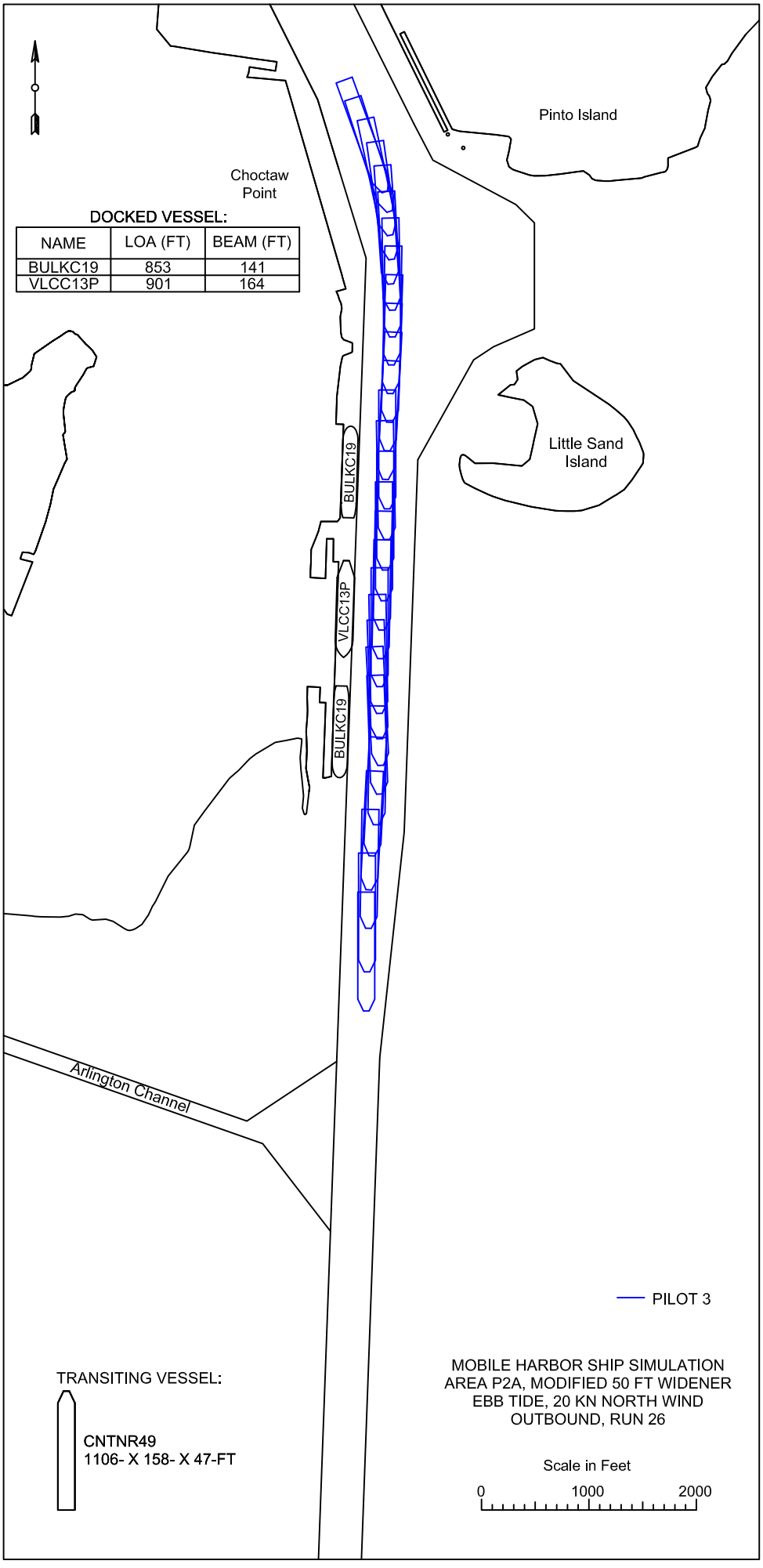

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
EBB TIDE, 20 KN NORTH WIND
OUTBOUND, RUN 26
Scale in Feet
0
1000
2000

Plate 8

Informational Sheet Plate 8

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
26	P2A	Outbound	Ebb	20 knots N	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	This outbound run went well except the ship at #1 McDuffie moved due to my ship pushing it while passing.		2	3

McDuffie Information:

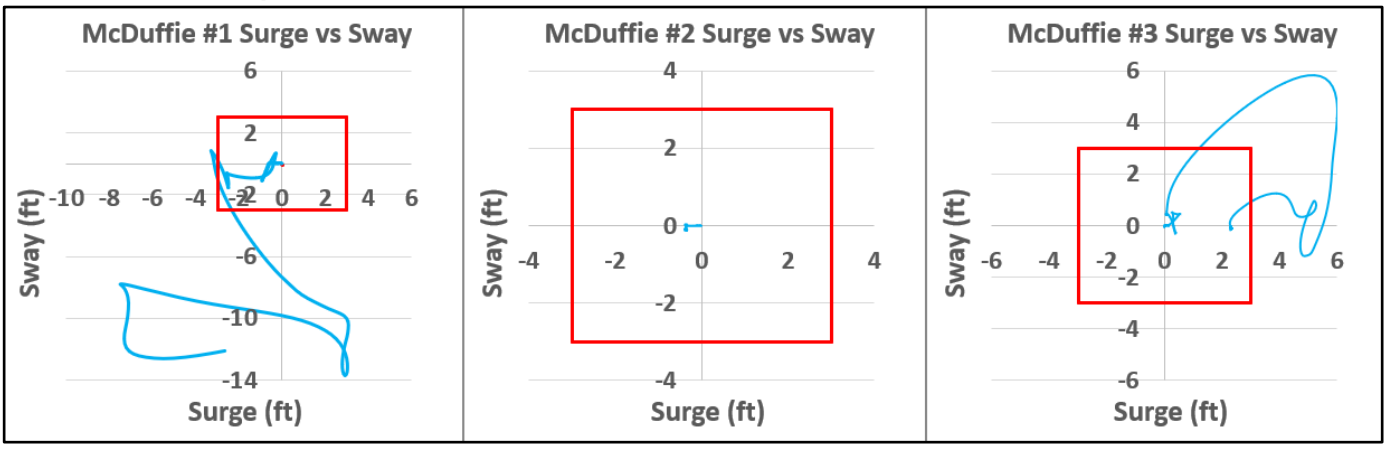
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	199	3.3	-7.5	-13.7	167	2.8	-0.4	-0.1	194	3.5	6.0	5.8

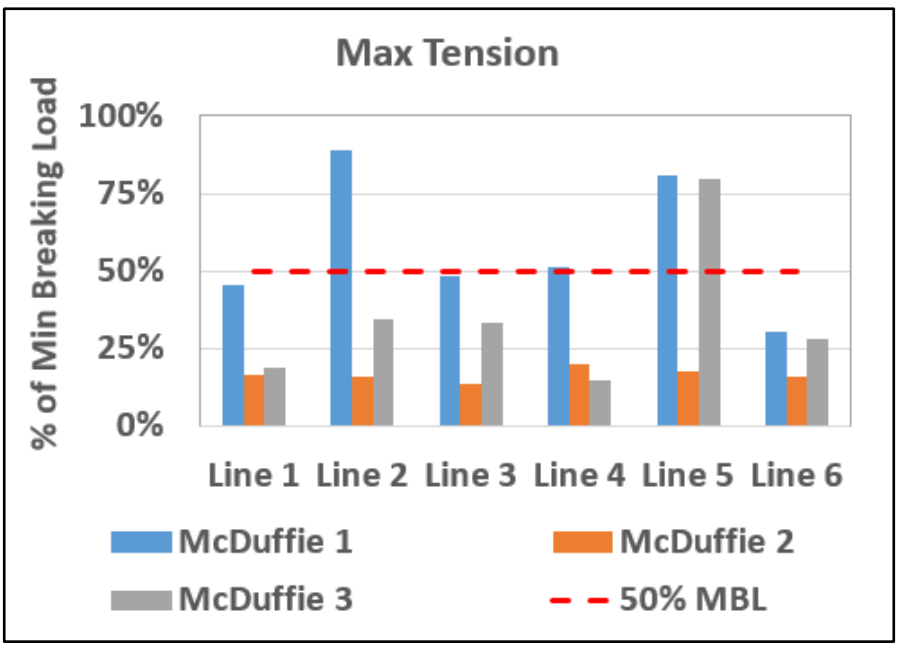
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	YES	YES	McDuffie #1 & #3

Informational Graphs Plate 8

Pilot #3 Repetition #1:





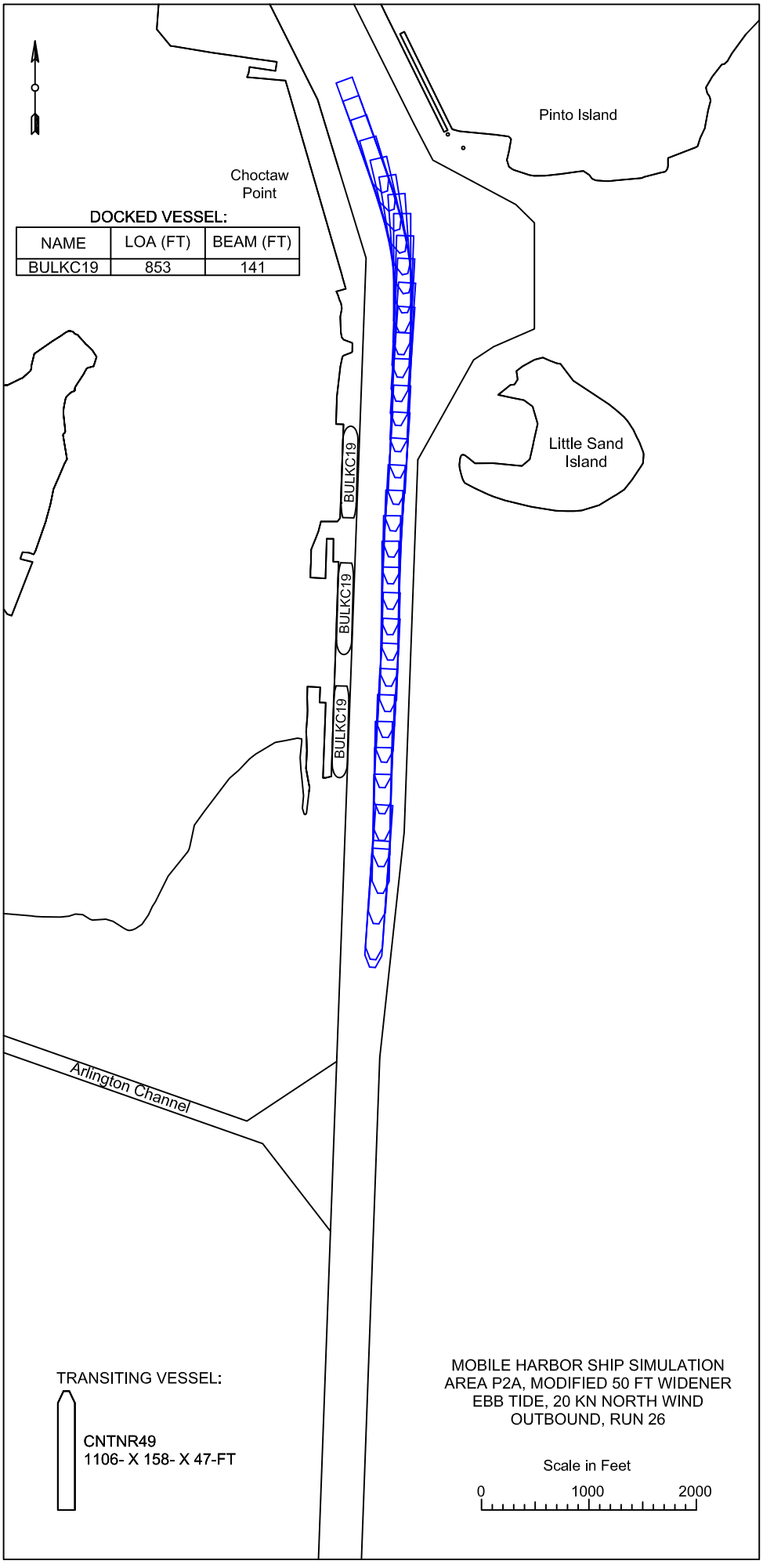

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
EBB TIDE, 20 KN NORTH WIND
OUTBOUND, RUN 26
Scale in Feet
0
1000
2000

Plate 8B

Informational Sheet Plate 8B

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
26	P2A	Outbound	Ebb	20 knots N	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	After running the 100 ft. widener, this seemed too much like no widener at all. Still, I feel this size ship is too close to McDuffie ships!		2	2

McDuffie Information:

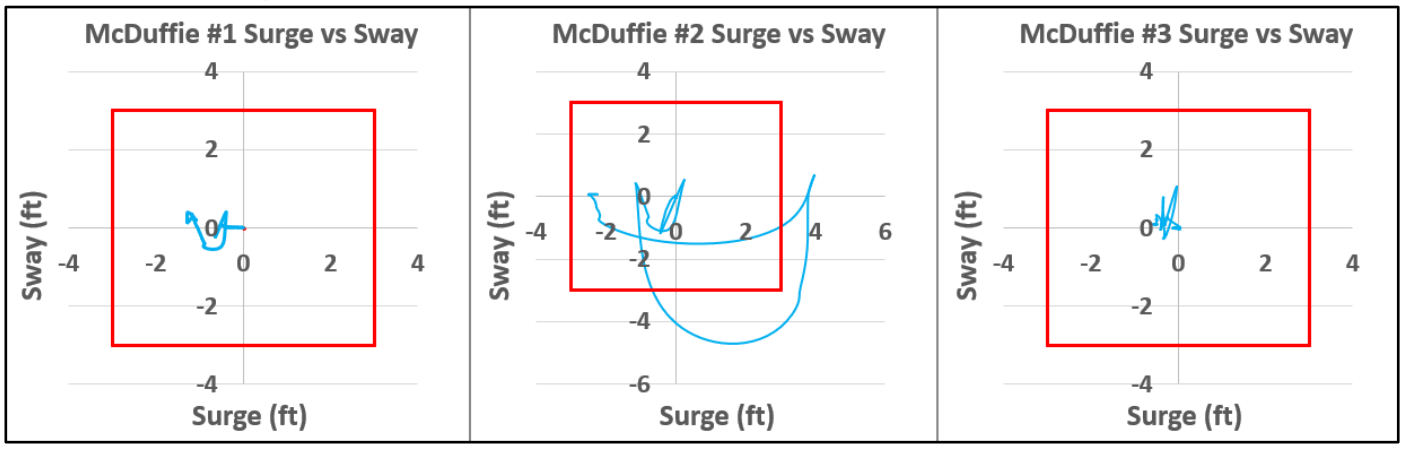
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	264	2.8	-1.3	-0.6	268	2.5	4.0	-4.7	291	2.5	-0.6	1.0

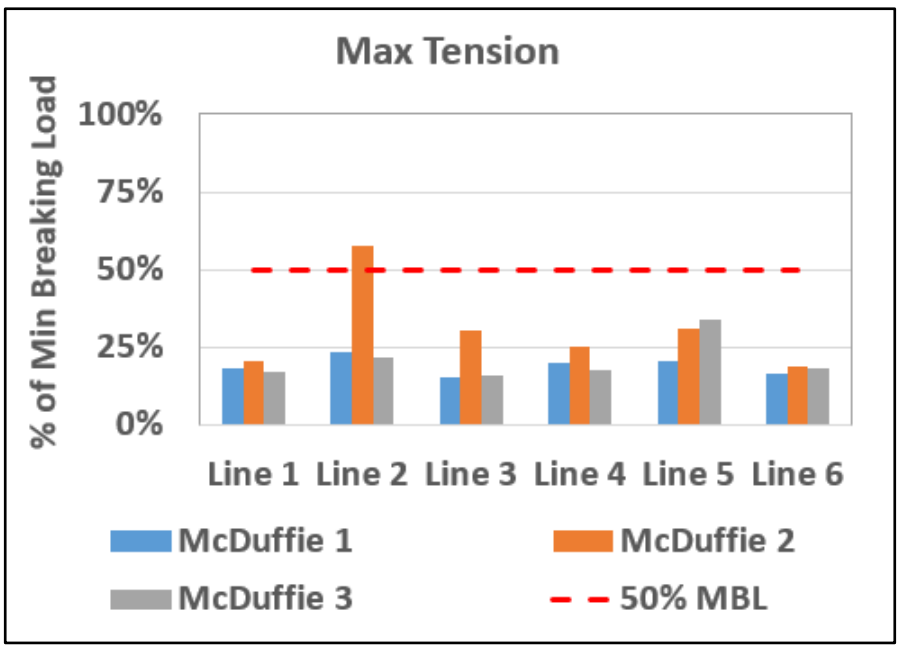
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	YES	YES	McDuffie #2

Informational Graphs Plate 8B

Pilot #3 Repetition #2:





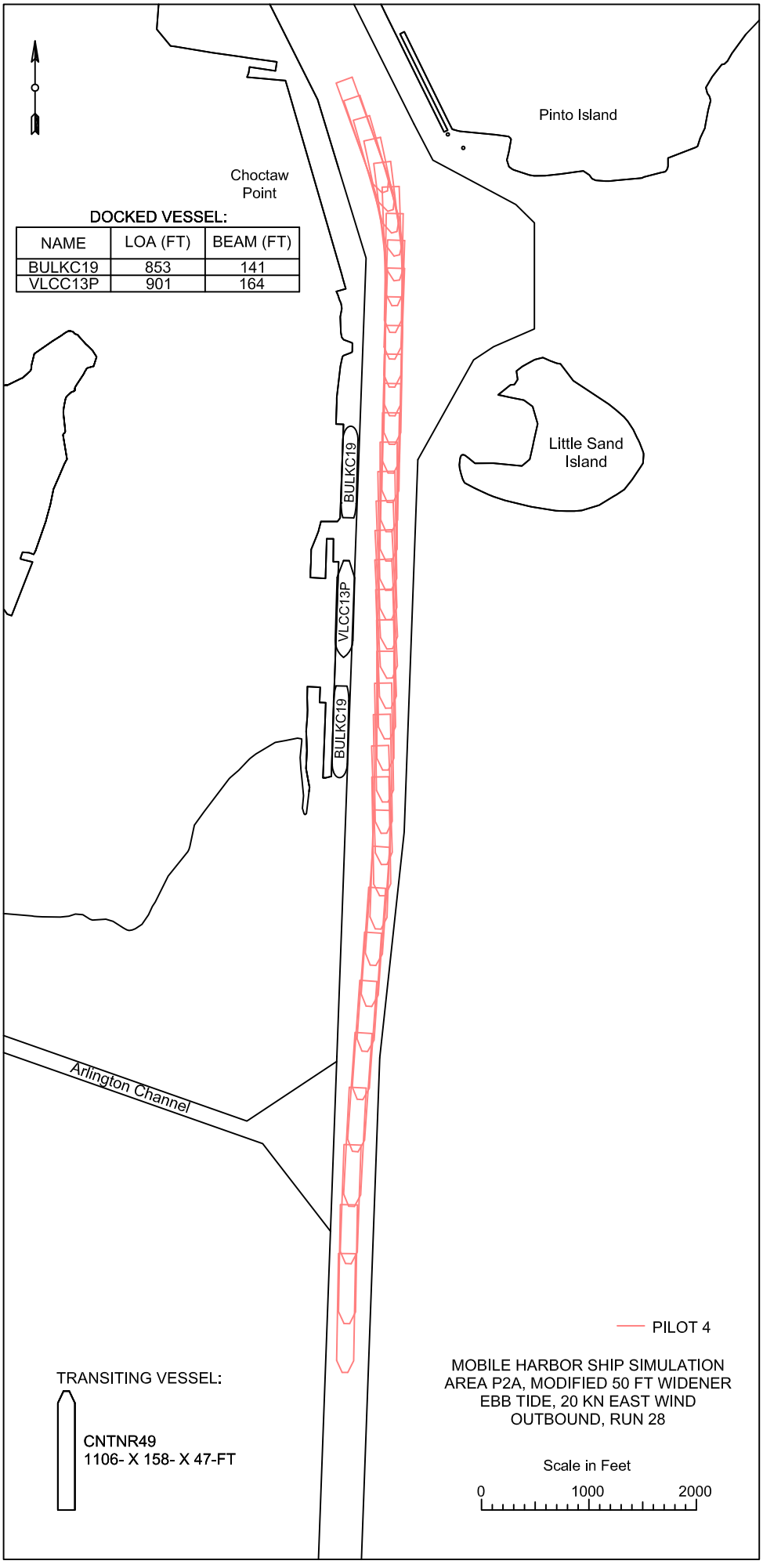

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 4
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
EBB TIDE, 20 KN EAST WIND
OUTBOUND, RUN 28
Scale in Feet
0
1000
2000

Plate 9

Informational Sheet Plate 9

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
28	P2A	Outbound	Ebb	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
4	With 2 kts of ebb tide, had to use tug earlier and stronger to control speed and more throughout exercise passing McDuffie. Felt little set to the west as opposed to east in previous exercises. Probably because of strong ebb which typically sets you to the west.		2	1

McDuffie Information:

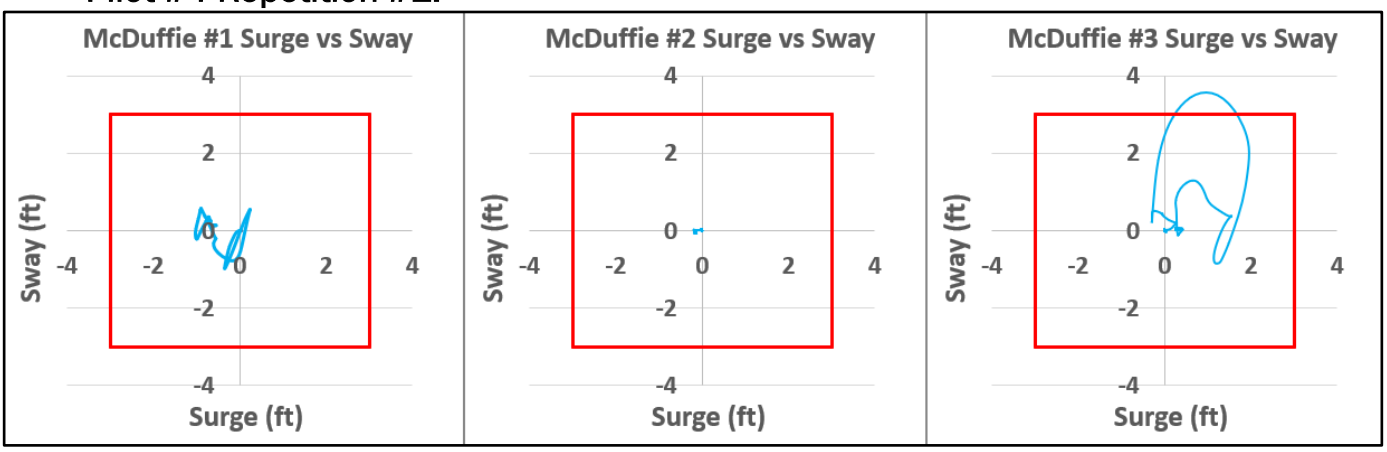
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
4	260	3.9	-1.0	-1.0	218	3.3	-0.2	0.0	228	3.4	2.0	3.6

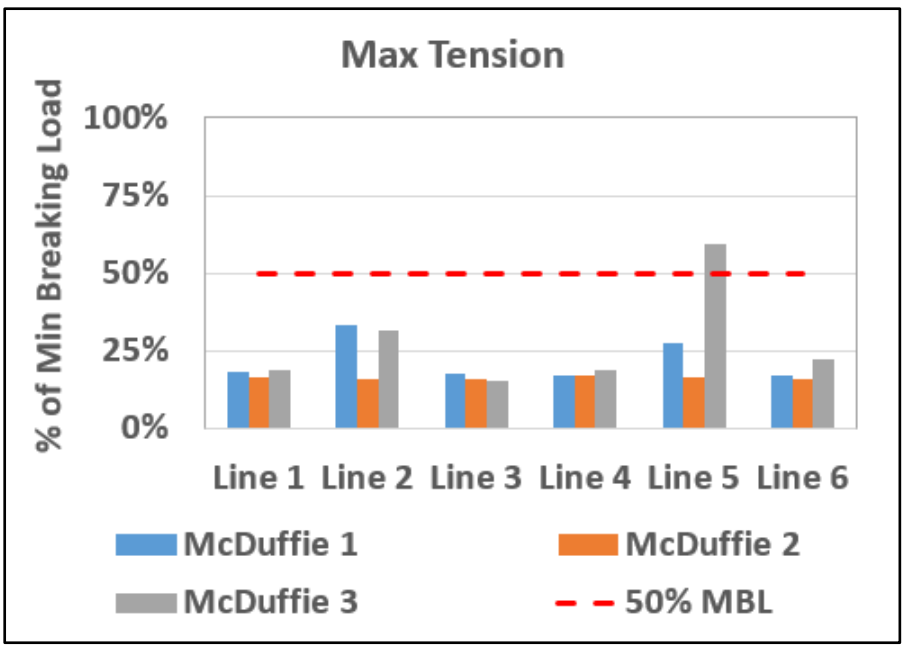
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
4	YES	YES	McDuffie #3

Informational Graphs Plate 9

Pilot #4 Repetition #1:





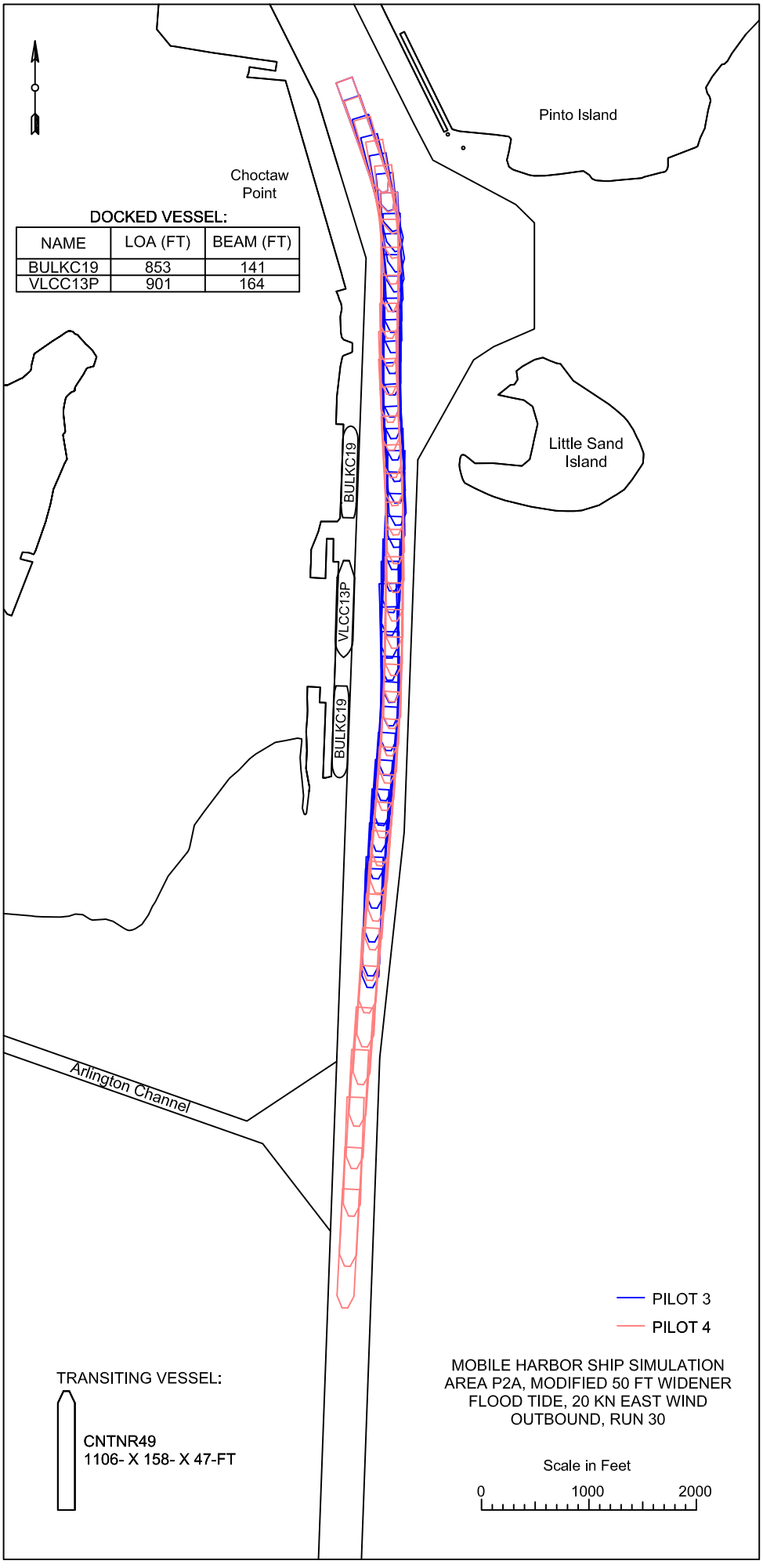

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
FLOOD TIDE, 20 KN EAST WIND
OUTBOUND, RUN 30
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 10

Informational Sheet Plate 10

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
30	P2A	Outbound	Flood	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	On this run, I feel the need to turn west, to continue center of safe water, will put a good deal of stress on mooring lines on the vessel at #1 McDuffie.		2	2
4	No issue controlling heading or speed. Minimal tug use to achieve desired speed.		1	1

McDuffie Information:

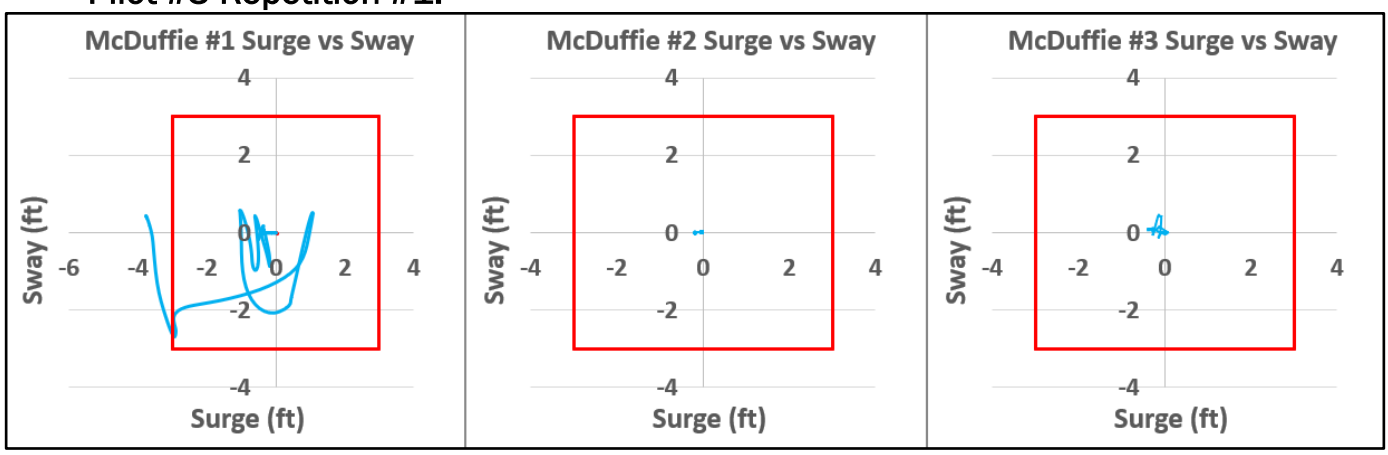
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	289	4.8	-3.8	-2.7	253	4.3	-0.2	0.0	275	4.4	-0.4	0.5
4	312	5.2	0.3	-0.8	288	5.6	-0.6	-0.1	255	5.7	0.8	2.7

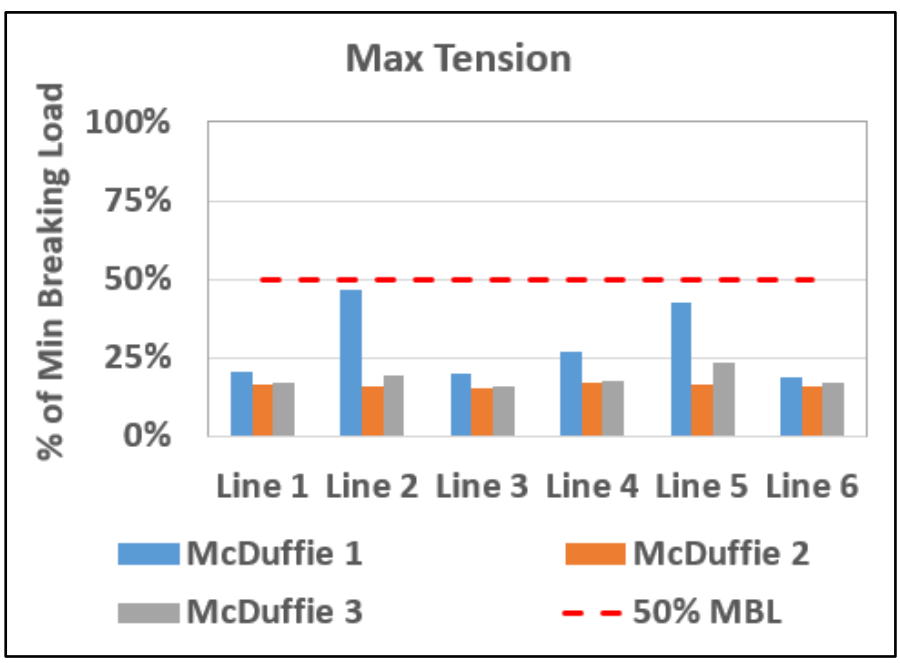
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	YES	McDuffie #1
4	YES	NO	McDuffie #3

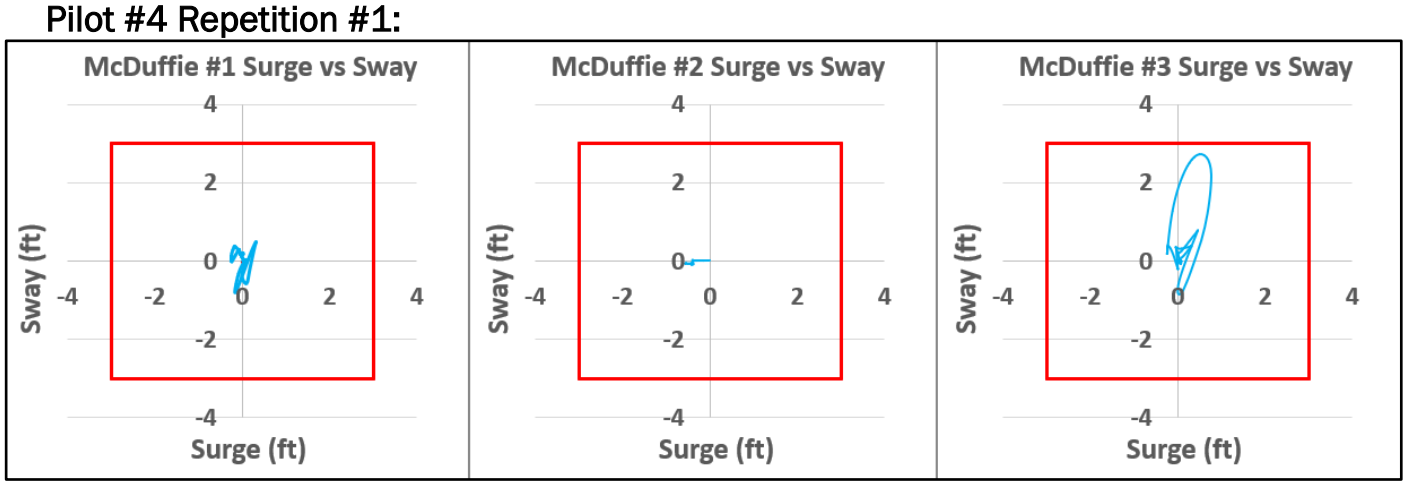
Informational Graphs Plate 10

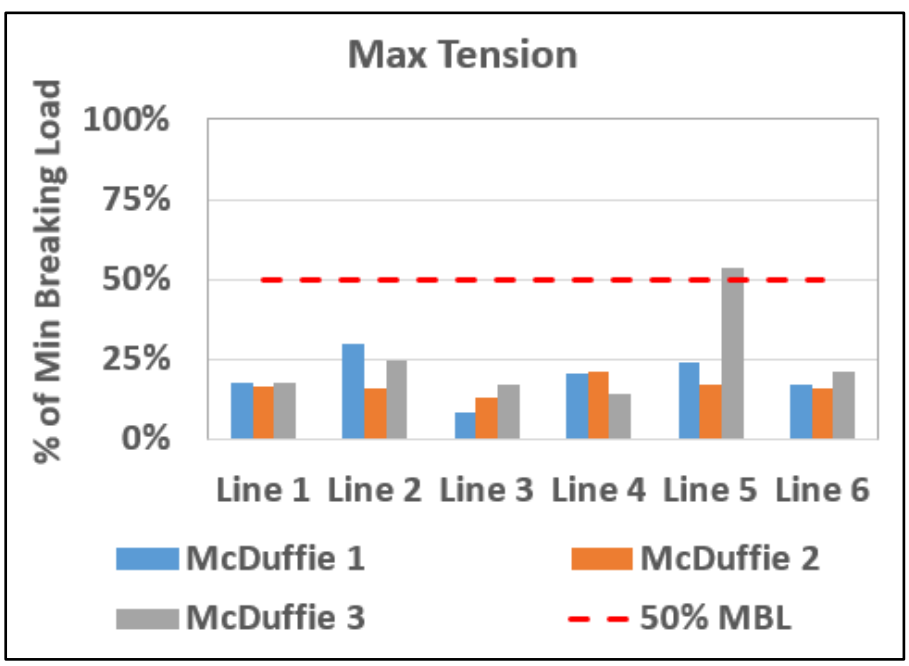
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





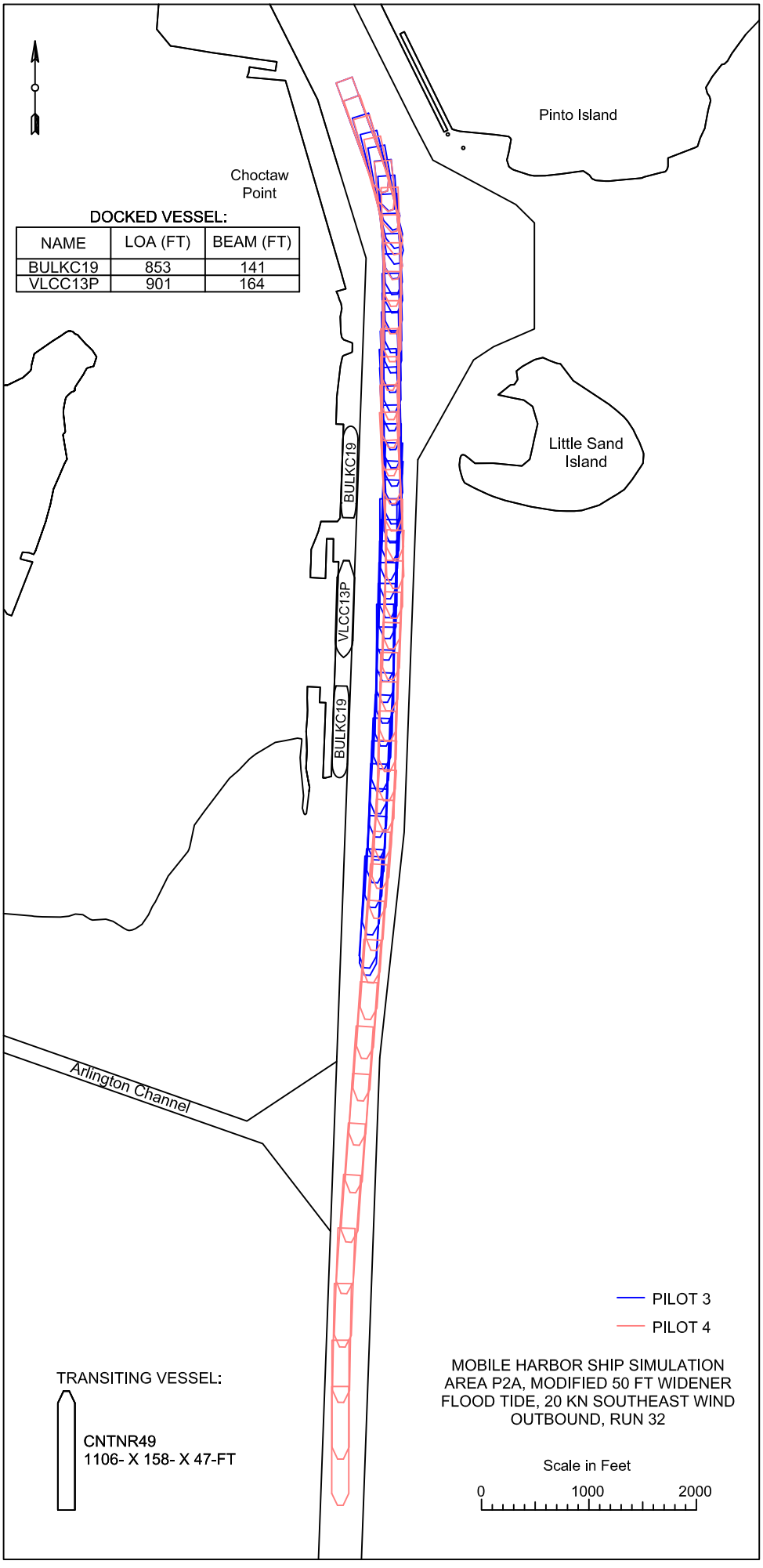

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P2A, MODIFIED 50 FT WIDENER
FLOOD TIDE, 20 KN SOUTHEAST WIND
OUTBOUND, RUN 32
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 11

Informational Sheet Plate 11

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
32	P2A	Outbound	Flood	20 knots SE	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	During this run, I felt like my ship was too close the McDuffie 1,2, and 3. Also feel like I needed to move to the west way too soon to stay in deep water when passing McDuffie 1.	Winches not released until ~3min in	3	3
4	Felt set to east at McDuffie and had to use more rudder and power on engine to hold course. Otherwise, able to control speed with minimal use of tug.		2	1

McDuffie Information:

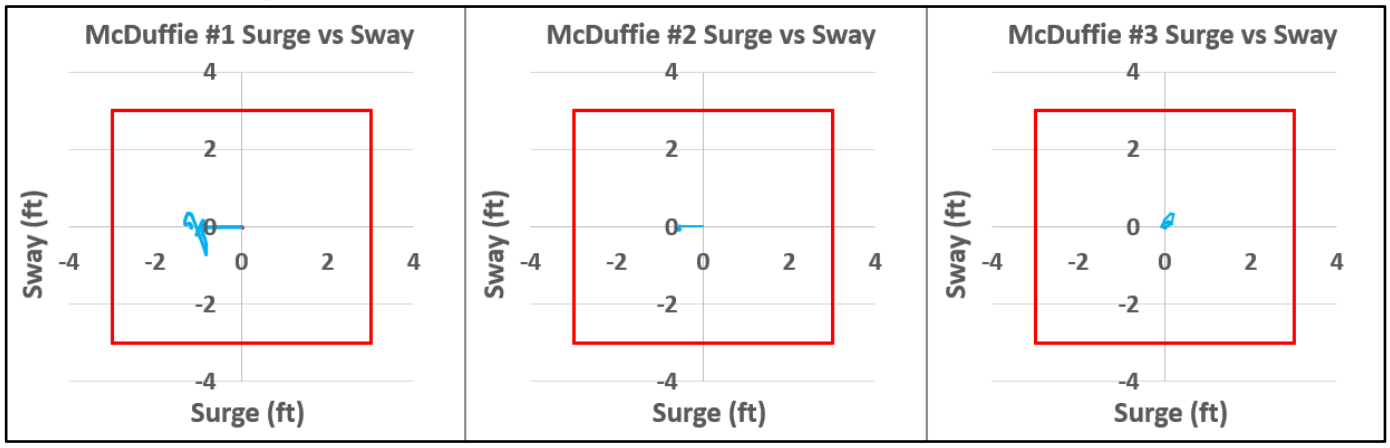
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	241	4.2	-1.3	-0.7	223	4	-0.6	-0.1	252	3.6	0.2	0.3
4	292	5.5	3.5	-2.4	280	5.8	-0.2	0.0	244	5.2	0.5	1.5

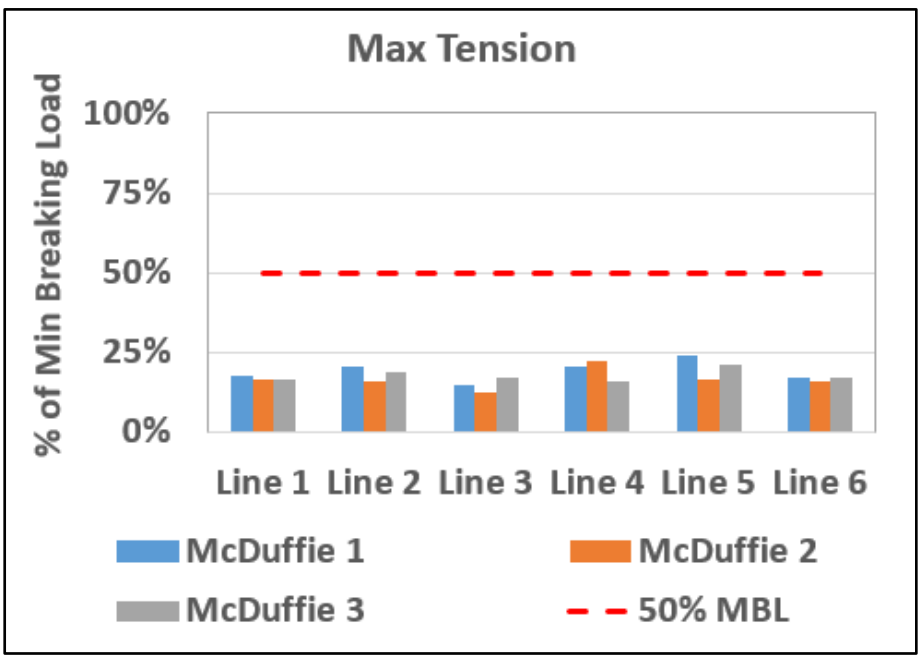
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	YES	McDuffie #1

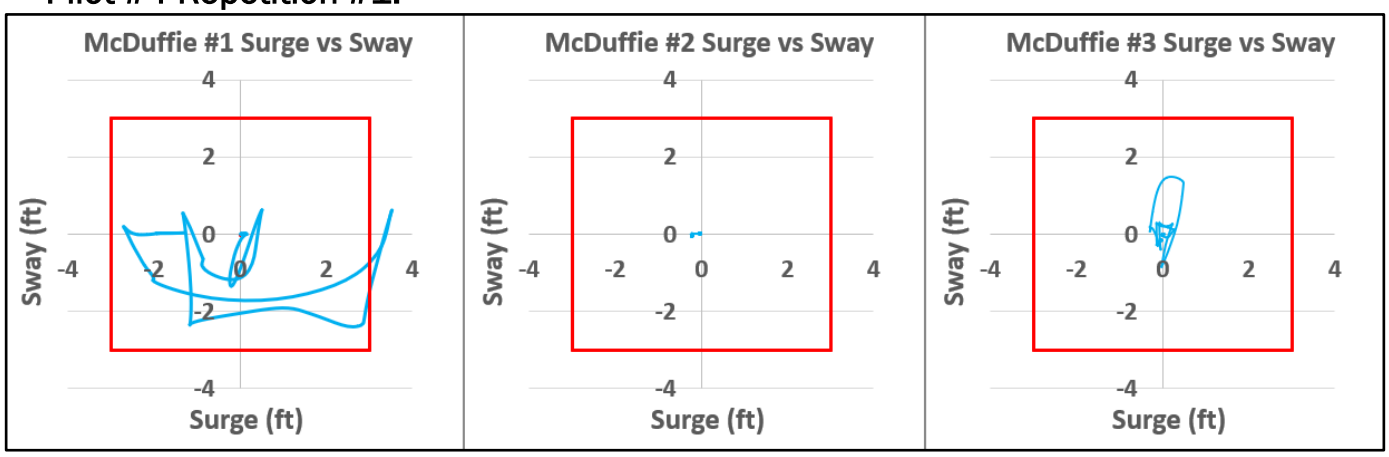
Informational Graphs Plate 11

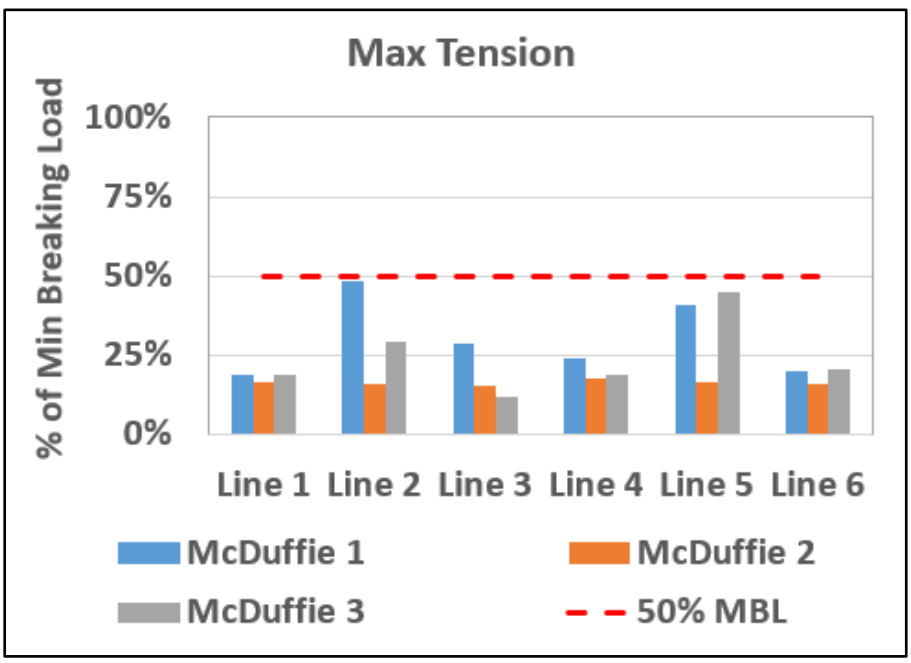
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





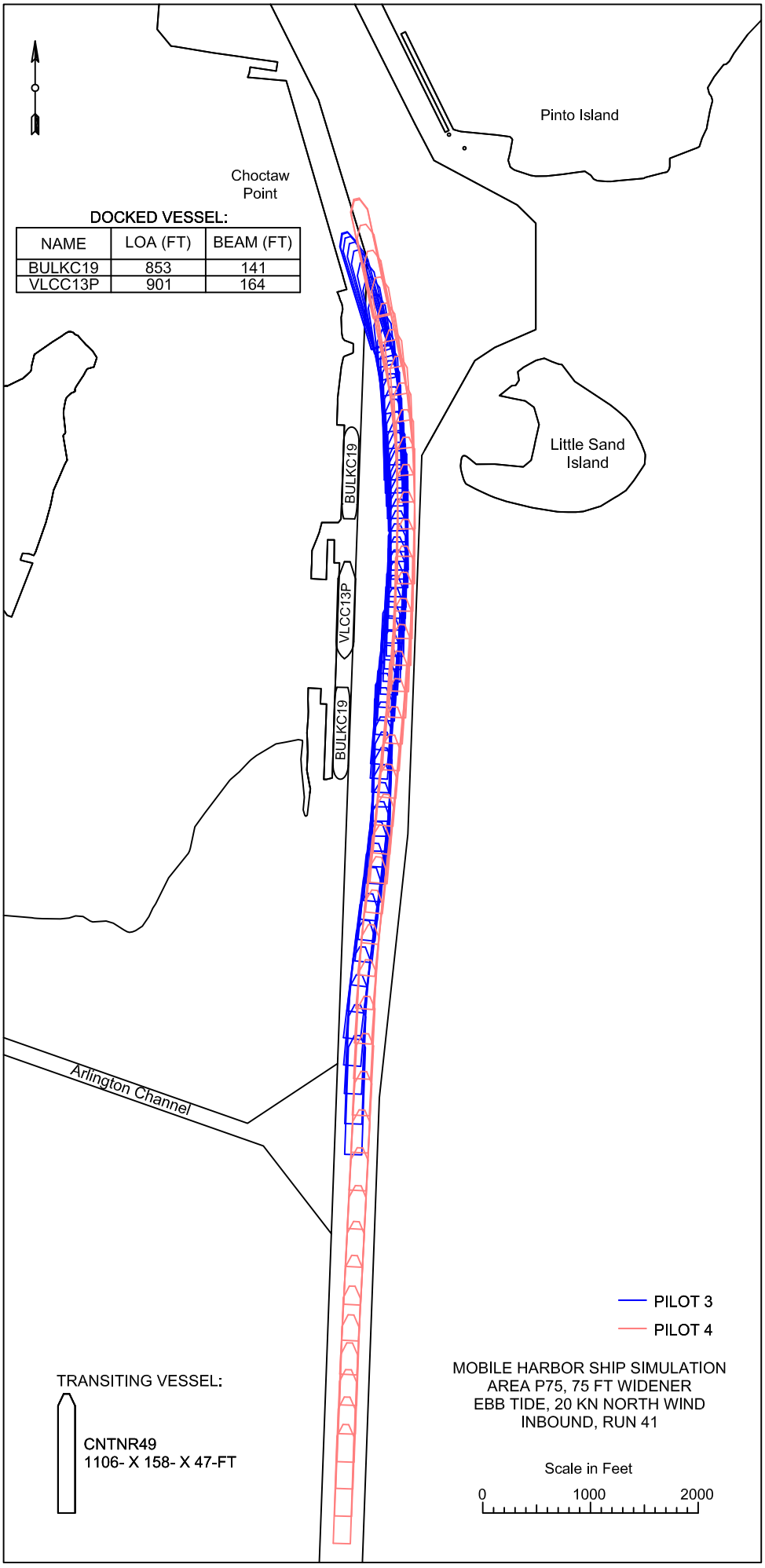

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P75, 75 FT WIDENER
EBB TIDE, 20 KN NORTH WIND
INBOUND, RUN 41
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 12

Informational Sheet Plate 12

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
41	P75	Inbound	Ebb	20 knots N	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	This run, the ship handled ok. I don't like to use a lot of the ship's engines in this area. I would rather use the tug and I still find I use the tug more than I should have to.	Winches release at 6 mins into simulation	2	3
4	Was able to control speed and heading with moderate tug use and engine bells.		2	1

McDuffie Information:

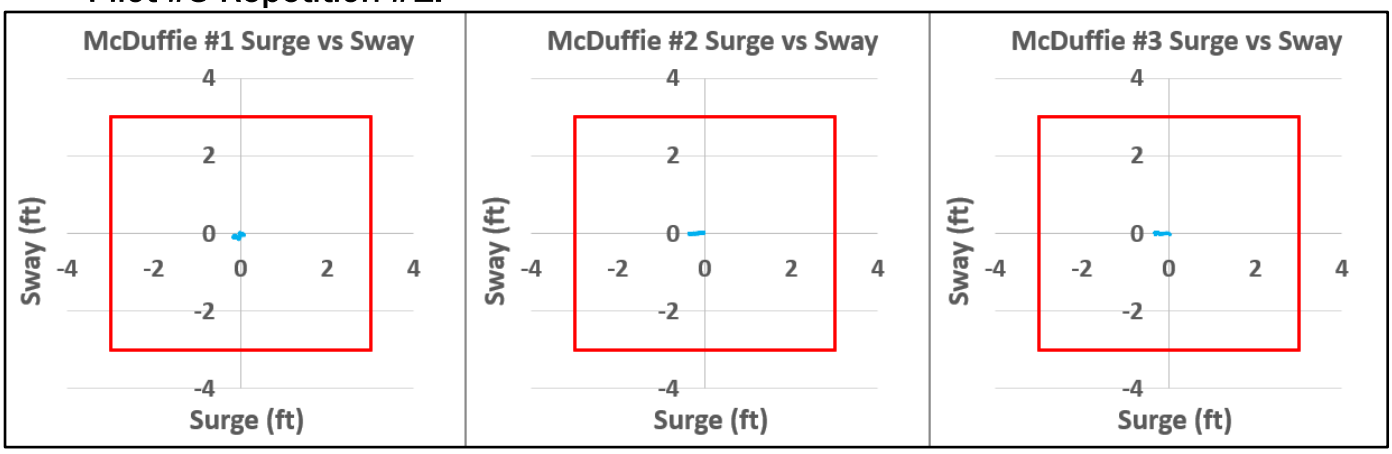
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	237	4.7	-0.2	-0.1	286	4.6	-0.4	0.0	281	4.4	-0.3	0.0
4	331	7.1	-0.3	-1.7	361	7	-0.2	0.0	358	7.2	-0.3	0.4

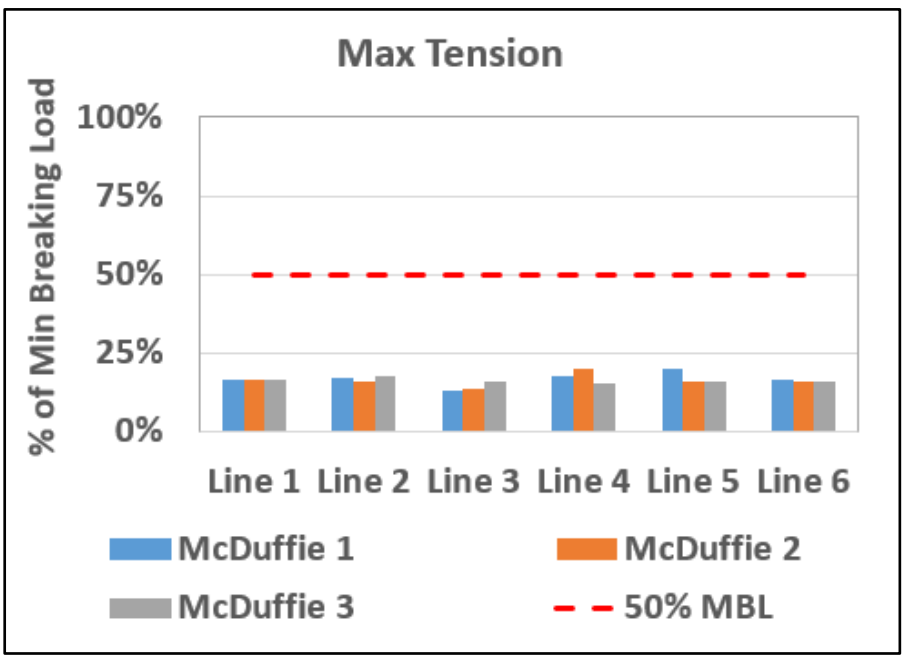
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

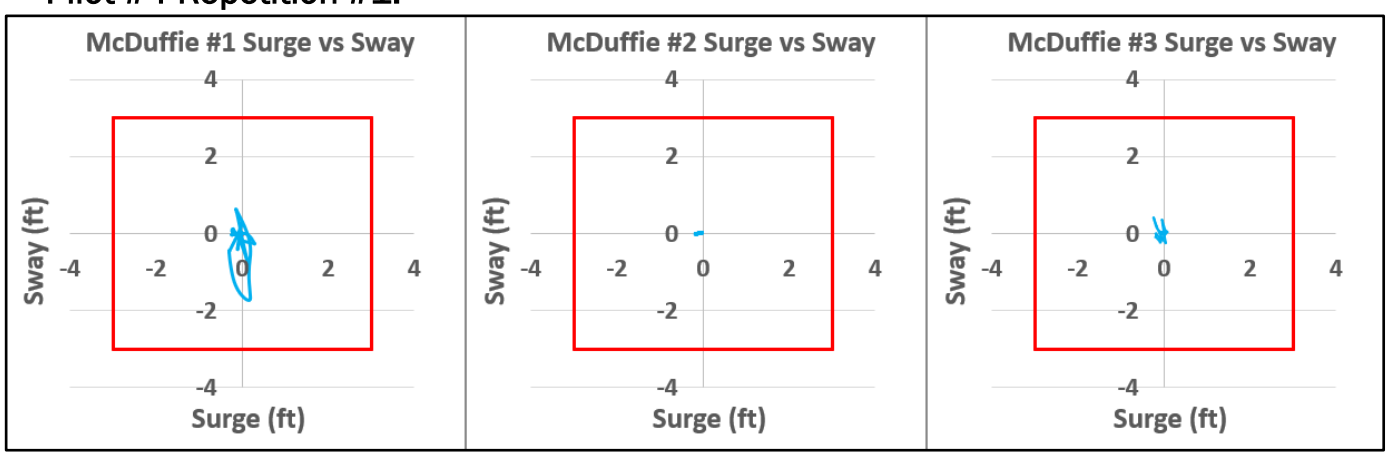
Informational Graphs Plate 12

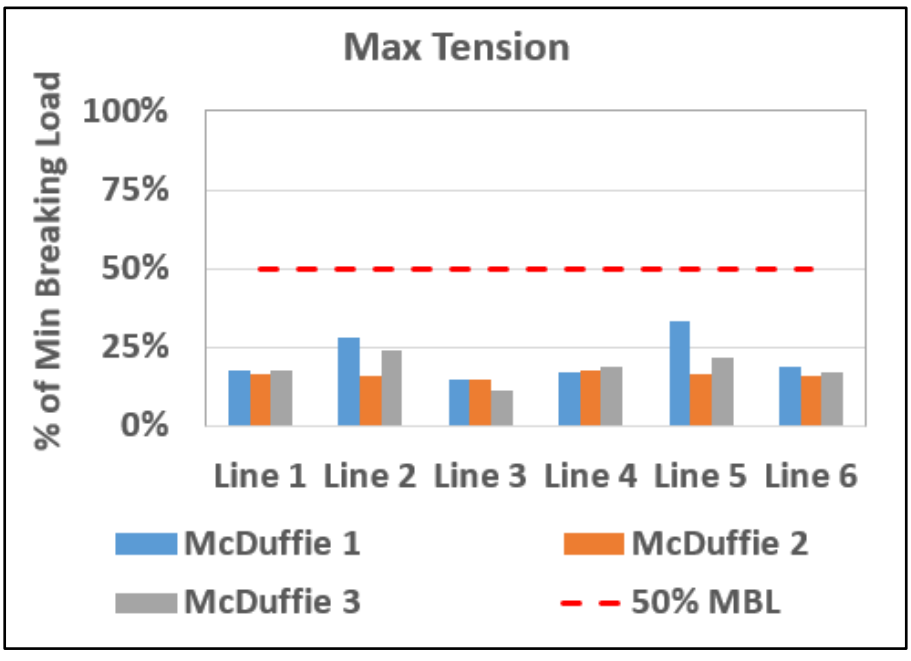
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





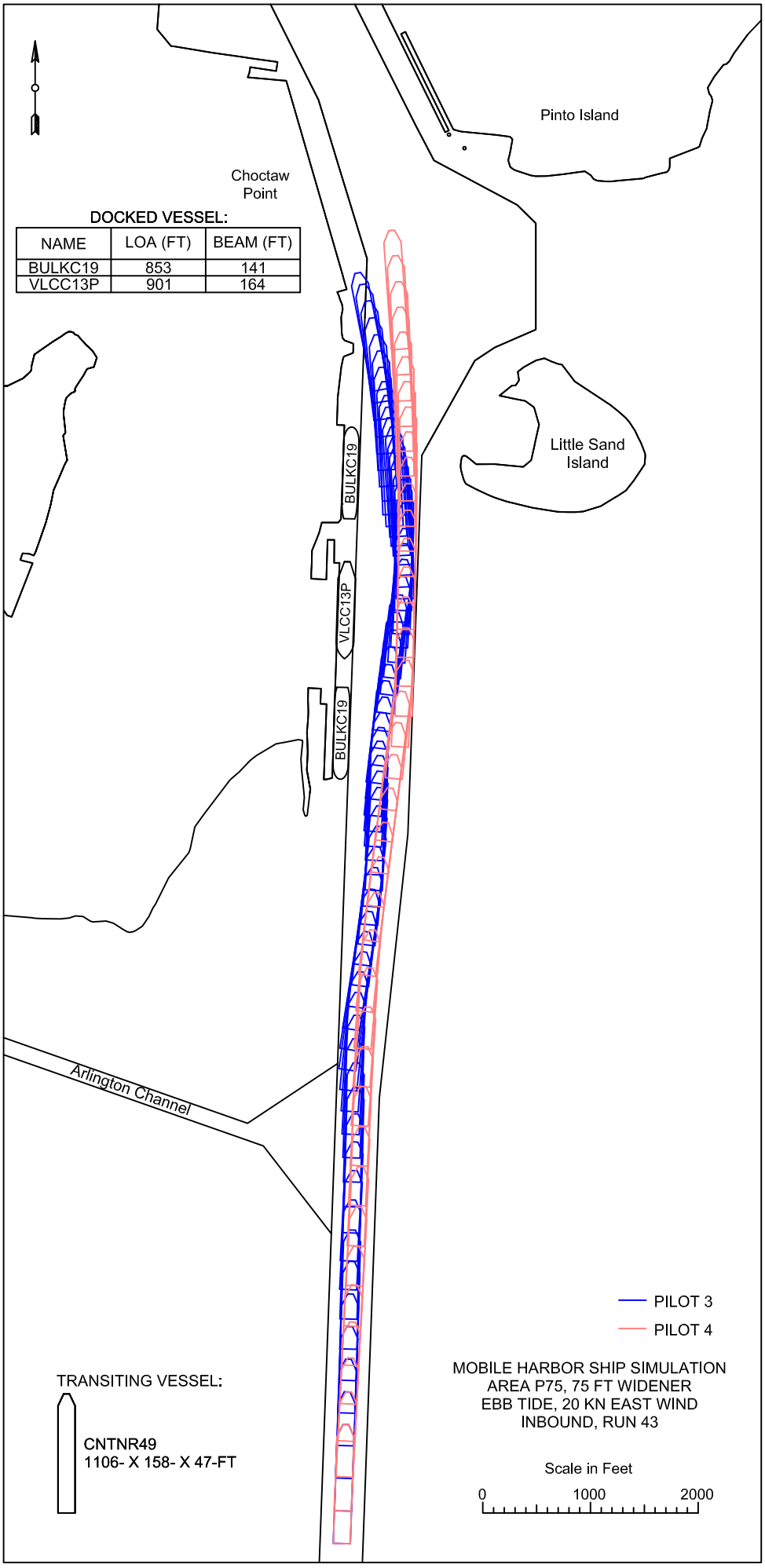

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P75, 75 FT WIDENER
EBB TIDE, 20 KN EAST WIND
INBOUND, RUN 43
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 13

Informational Sheet Plate 13

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
43	P75	Inbound	Ebb	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Was able to control heading and speed with moderate tug power use and engine bells. Set to starboard at lower end of McDuffie was felt little more pronounced.		2	1
4	The ship seemed to respond to rudder and tug work much better with more water on both sides.		1	2

McDuffie Information:

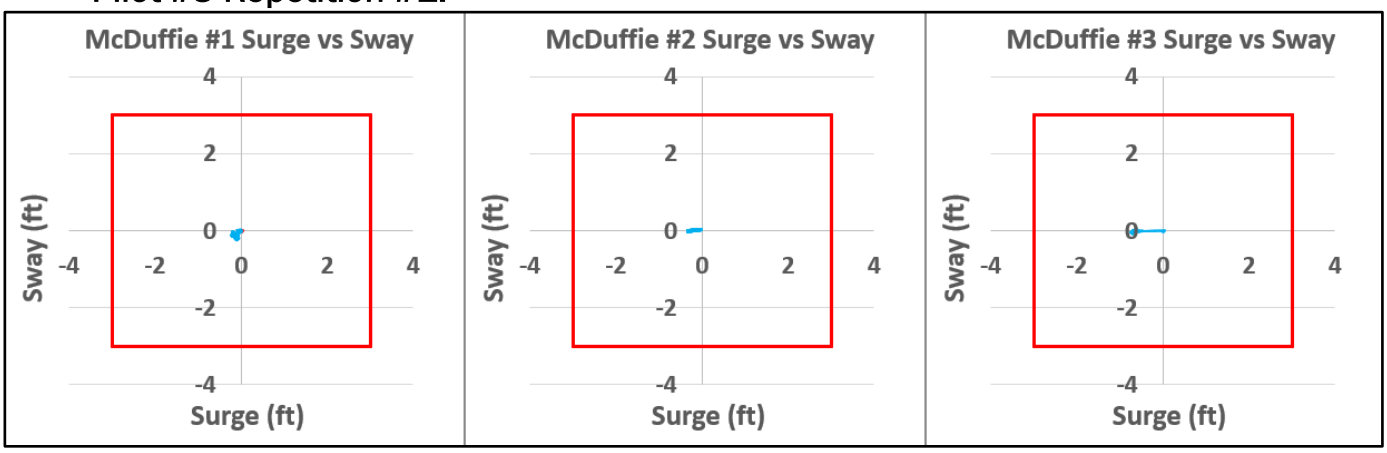
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	217	5	-0.2	-0.2	328	5	-0.3	0.0	247	3.9	-0.7	-0.1
4	373	7.7	-0.9	-2.8	395	7.3	-0.4	0.0	381	6.7	-0.4	0.2

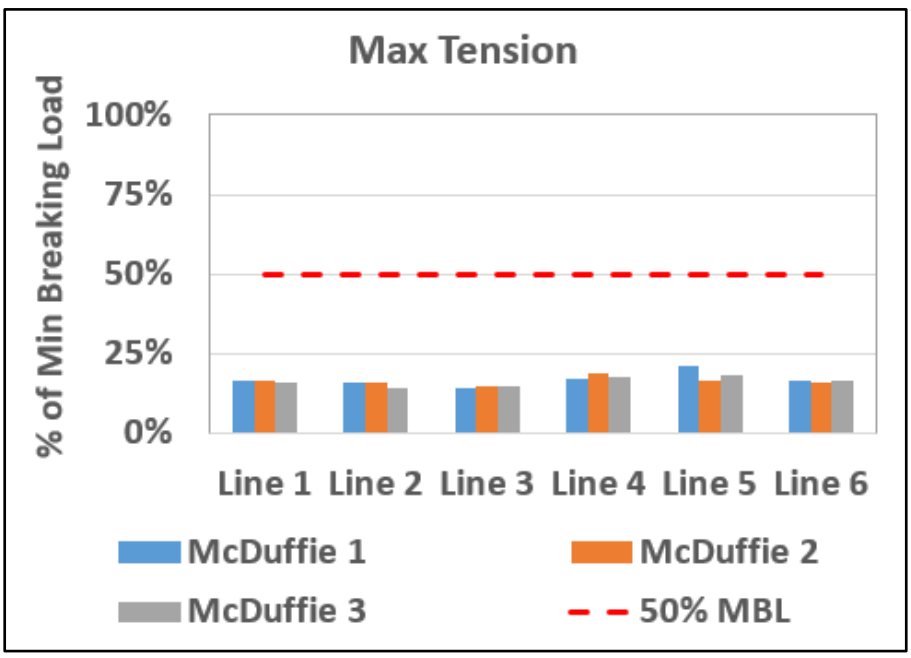
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

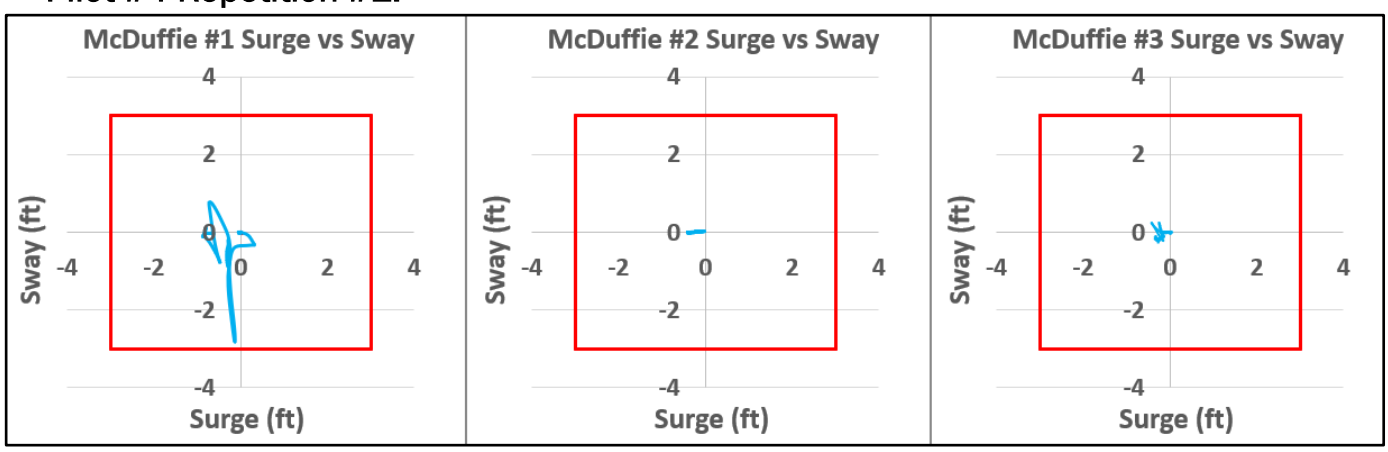
Informational Graphs Plate 13

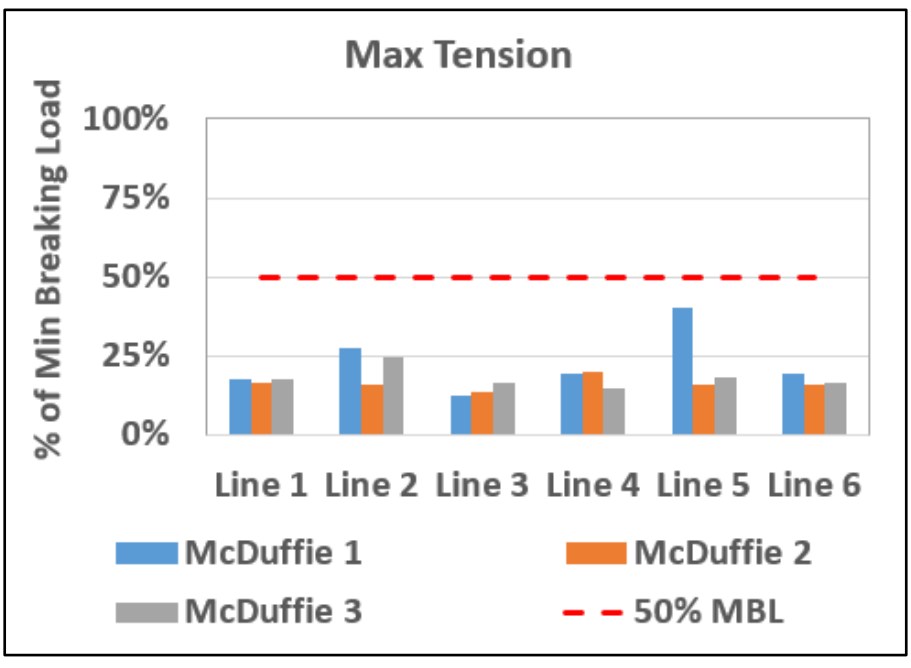
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





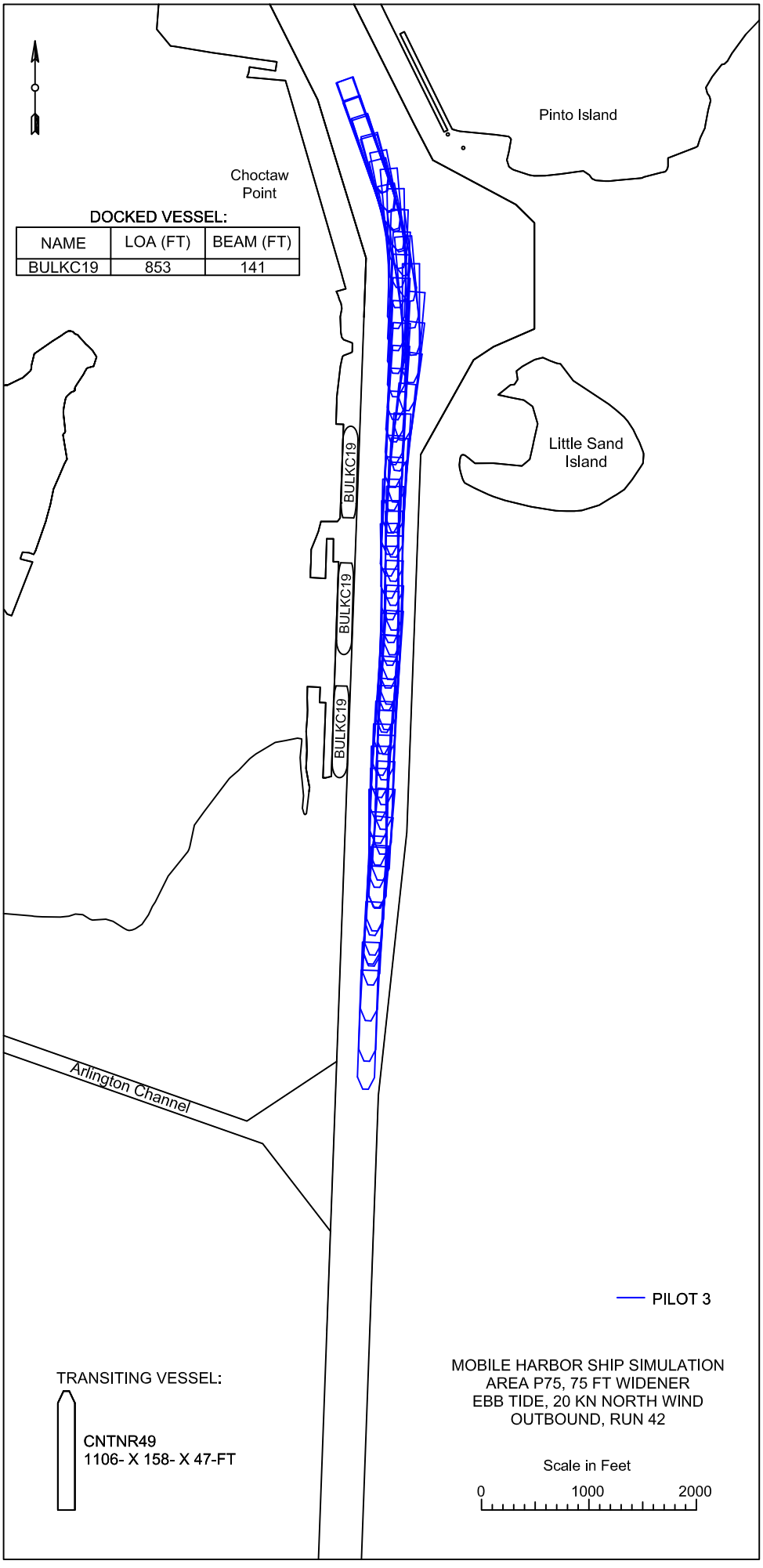

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P75, 75 FT WIDENER
EBB TIDE, 20 KN NORTH WIND
OUTBOUND, RUN 42
Scale in Feet
0
1000
2000

Plate 14

Informational Sheet Plate 14

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
42	P75	Outbound	Ebb	20 knots N	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Same comments as the run before. This outbound ship must move west to center of channel to close to #1 McDuffie.	Winches weren't released until after McDuffie #3 passing. Vessel parameter data was lost prior to 14 mins.	2	3
3	First turn to line up with the McDuffie reach. Could be difficult under slightly different conditions.		3	3

McDuffie Information:

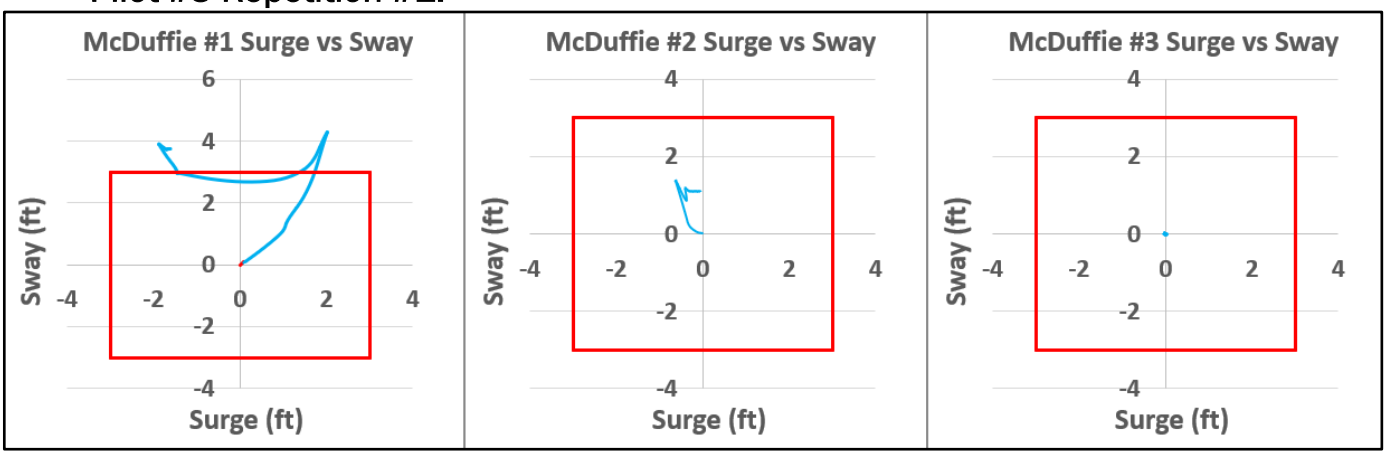
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	252	2	2.0	4.3	274	1.9	-0.6	1.4	265	1.8	0.0	0.0
3	272	2.5	-1.2	-0.9	291	2.4	3.6	-4.6	299	2.5	-0.7	1.1

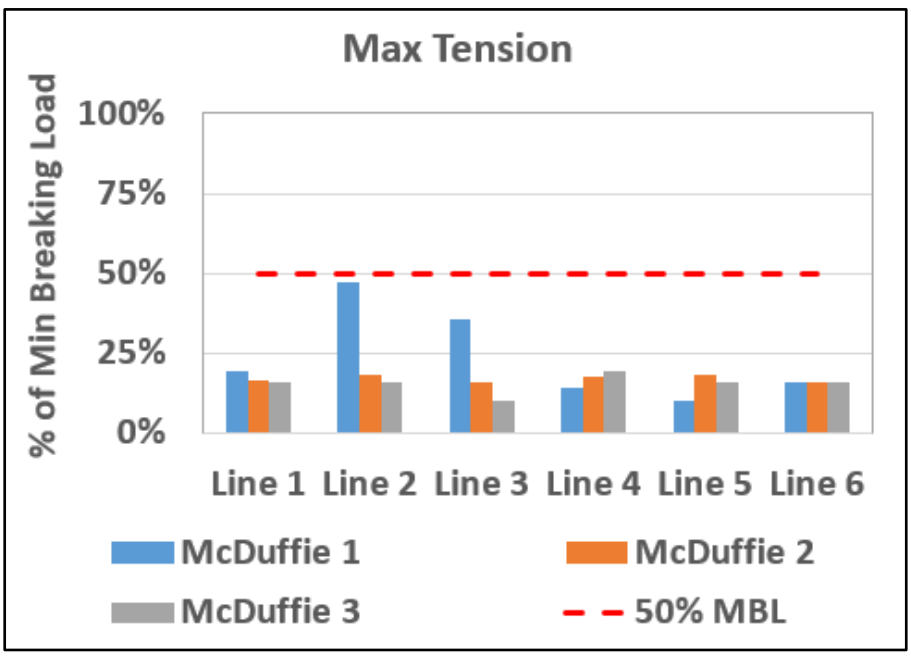
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	YES	McDuffie #1
3	NO	YES	McDuffie #2

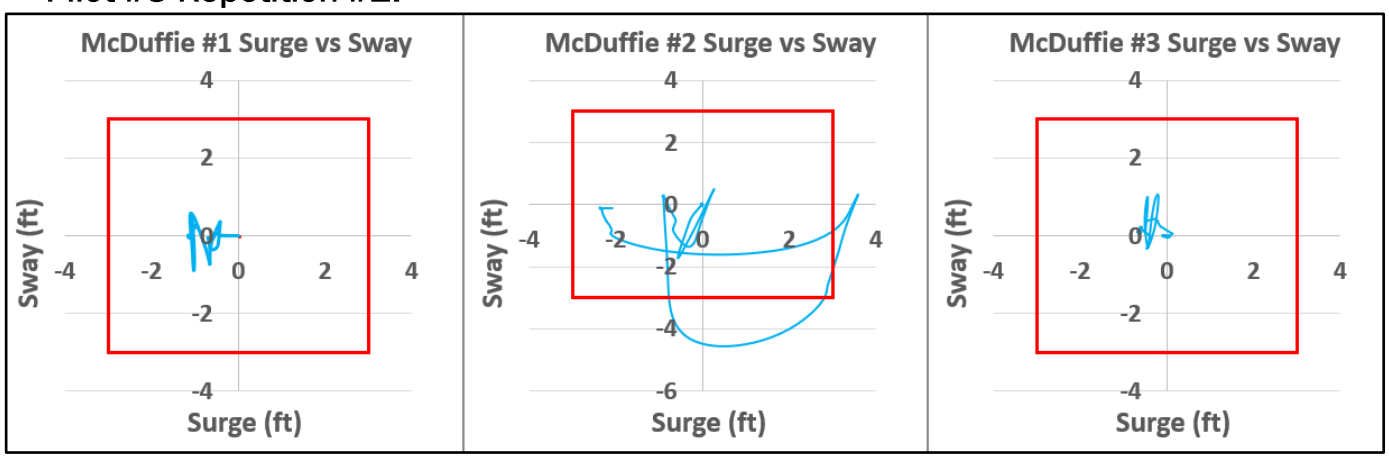
Informational Graphs Plate 14

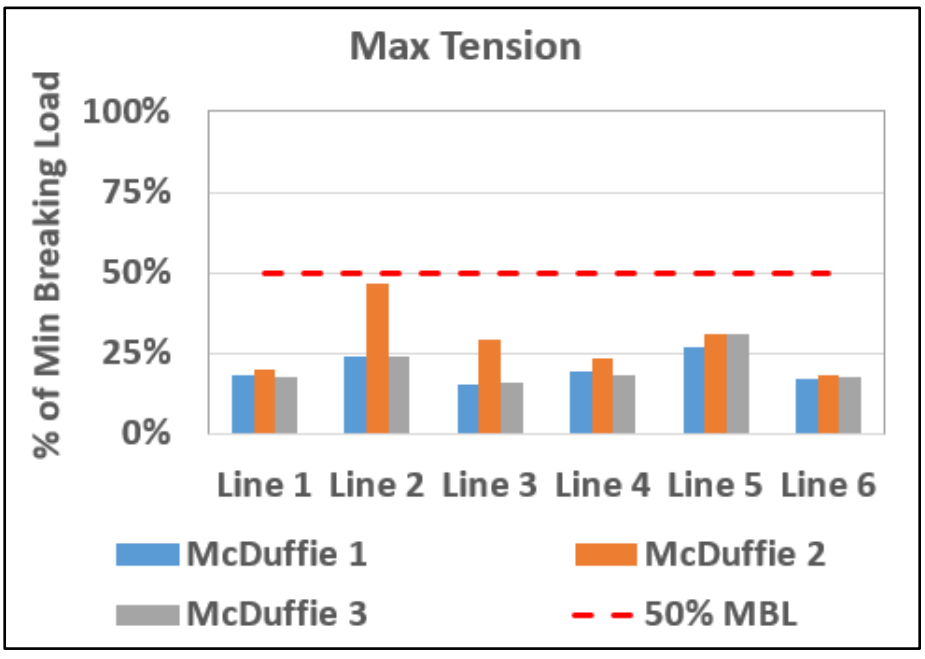
Pilot #3 Repetition #1:





Pilot #3 Repetition #2:





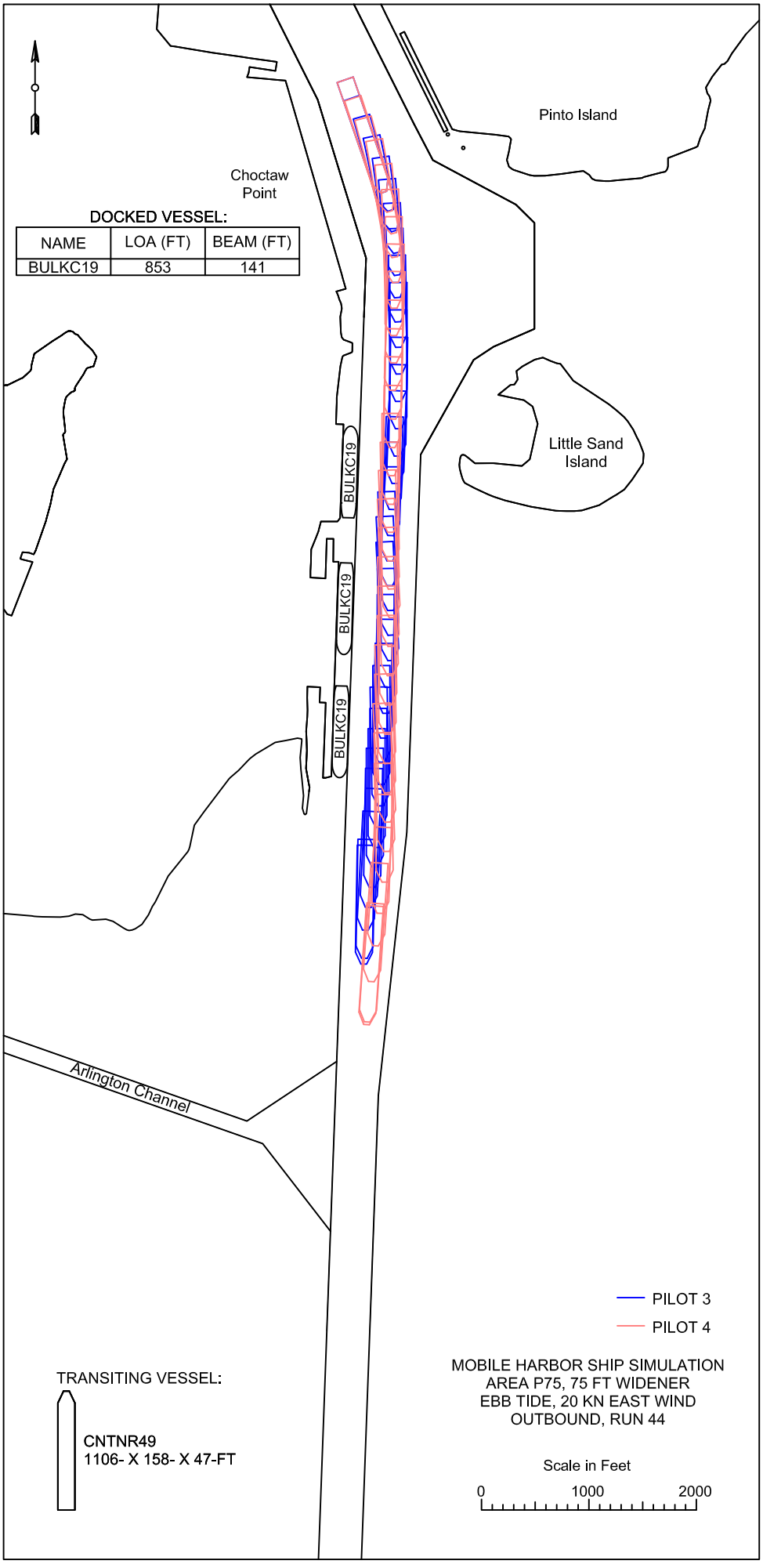

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P75, 75 FT WIDENER
EBB TIDE, 20 KN EAST WIND
OUTBOUND, RUN 44
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 15

Informational Sheet Plate 15

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
44	P75	Outbound	Ebb	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Outbound with an ebb tide & cross wind (east) I seem to work the tug more. I don't use the tug with 100ft as much.		2	2
4	Had to use tug on moderate power to control speed with stronger ebb. Was able to control heading fine with minimal to moderate engine bells.		2	2

McDuffie Information:

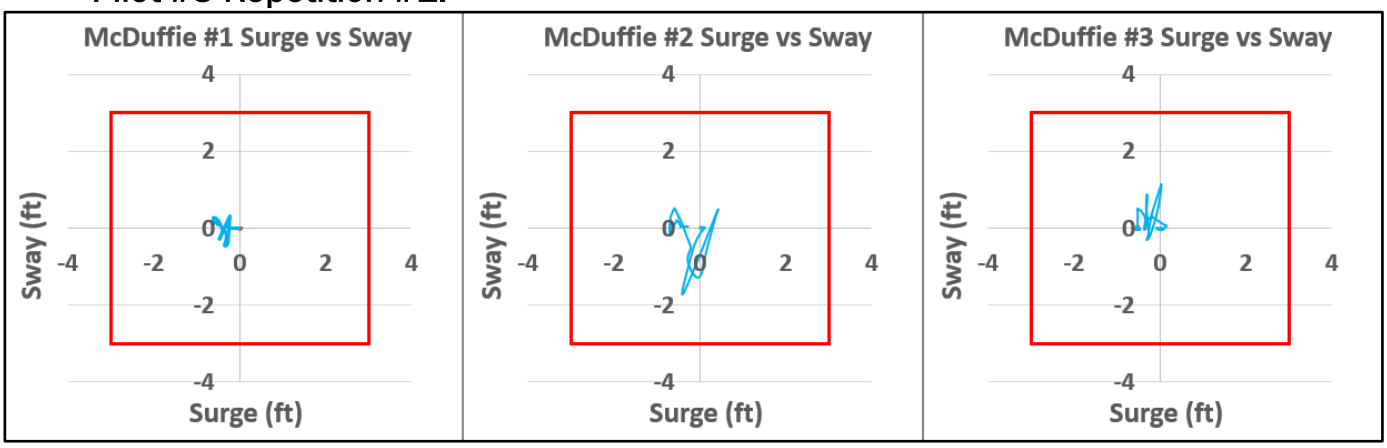
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	217	2	-0.6	-0.5	245	2.8	-0.7	-1.7	255	2.7	-0.6	1.2
4	268	3.5	-0.7	-1.0	255	3.2	7.6	-6.7	235	3.2	1.7	2.9

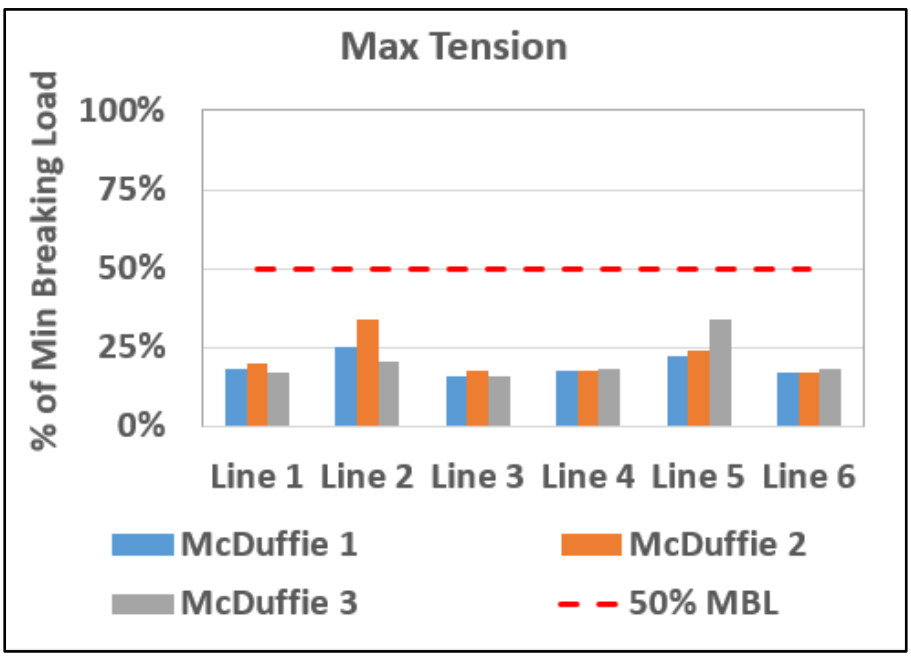
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	YES	YES	McDuffie #2 & #3

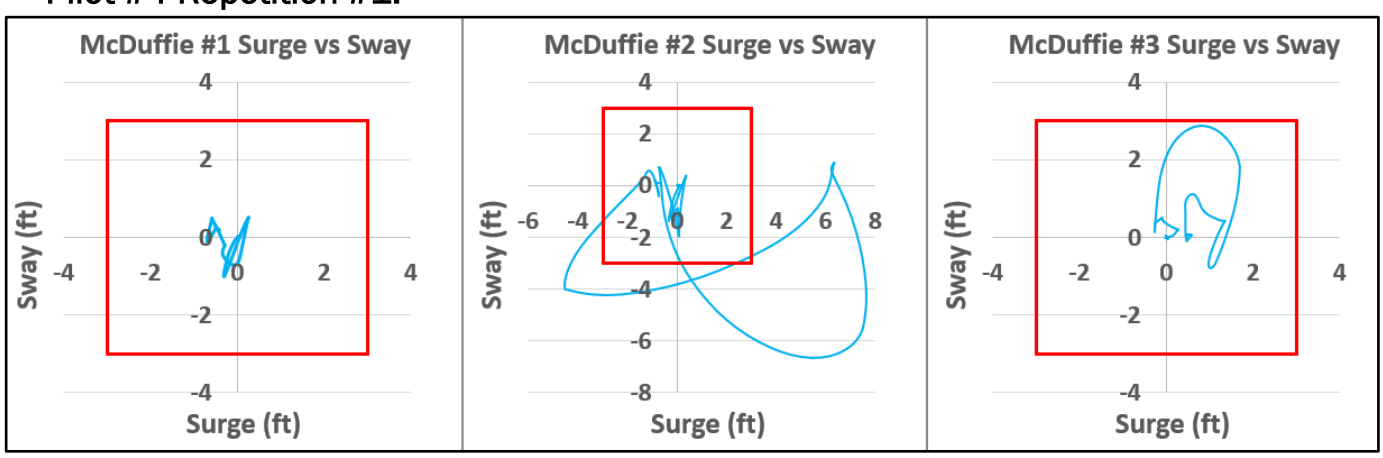
Informational Graphs Plate 15

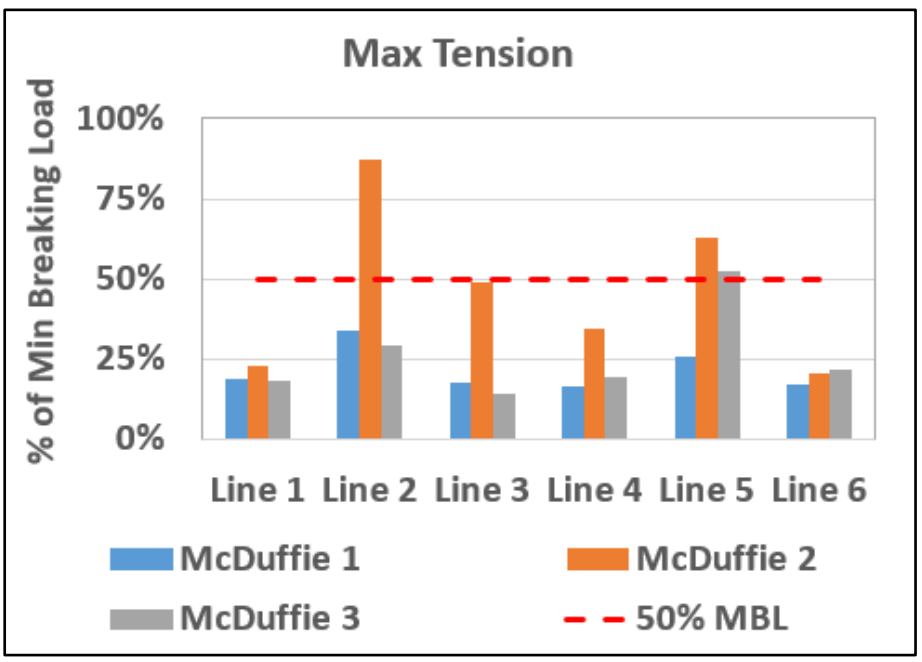
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





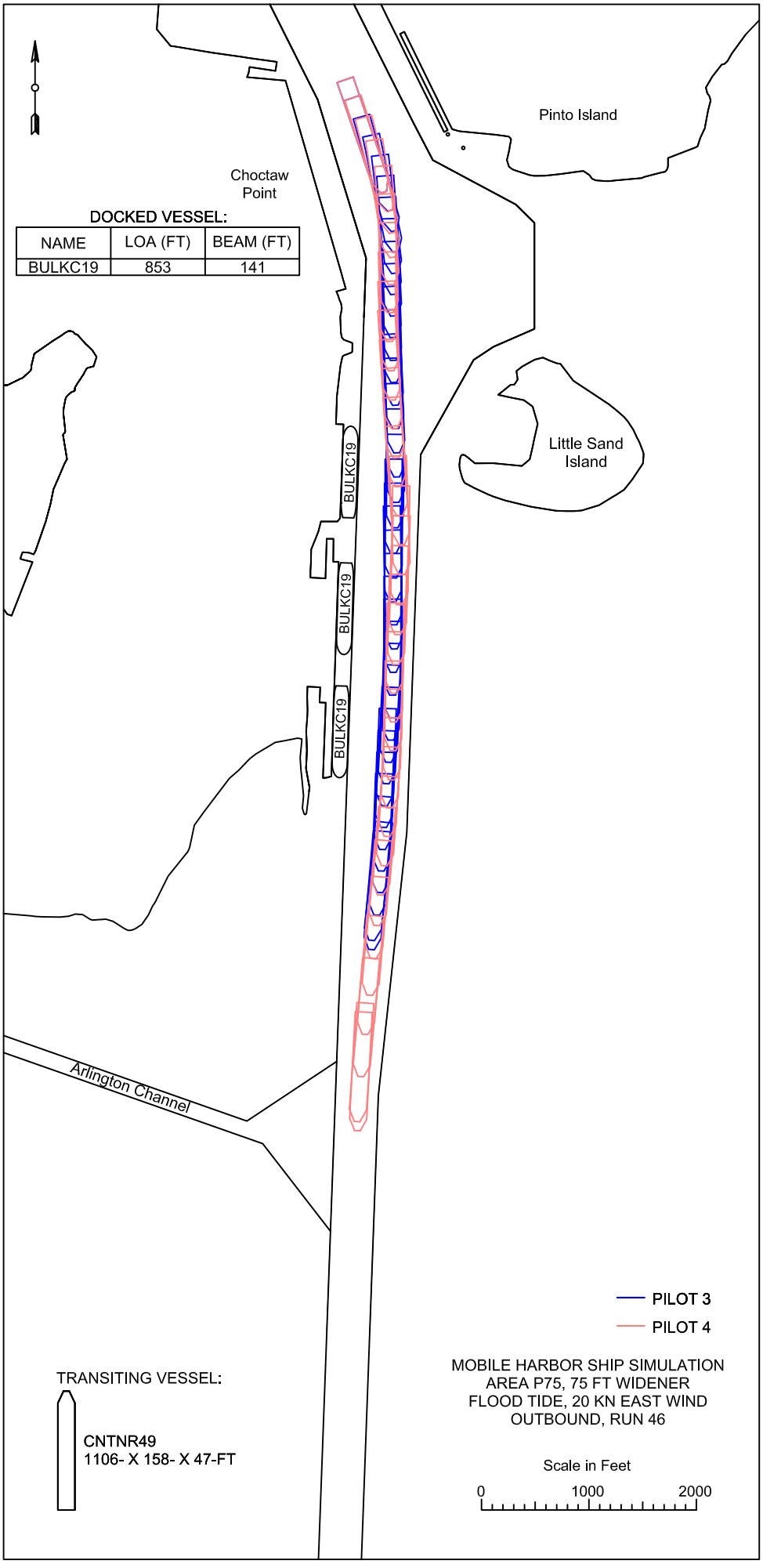

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P75, 75 FT WIDENER
FLOOD TIDE, 20 KN EAST WIND
OUTBOUND, RUN 46
Scale in Feet
0
1000
2000

Plate 16

Informational Sheet Plate 16

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
46	P75	Outbound	Flood	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	With the 75-ft widener, I find I still need to keep ships speed very low as to not damage McDuffie ships.		2	2
4	Able to control speed and heading quite well with minimal tug use.		1	1

McDuffie Information:

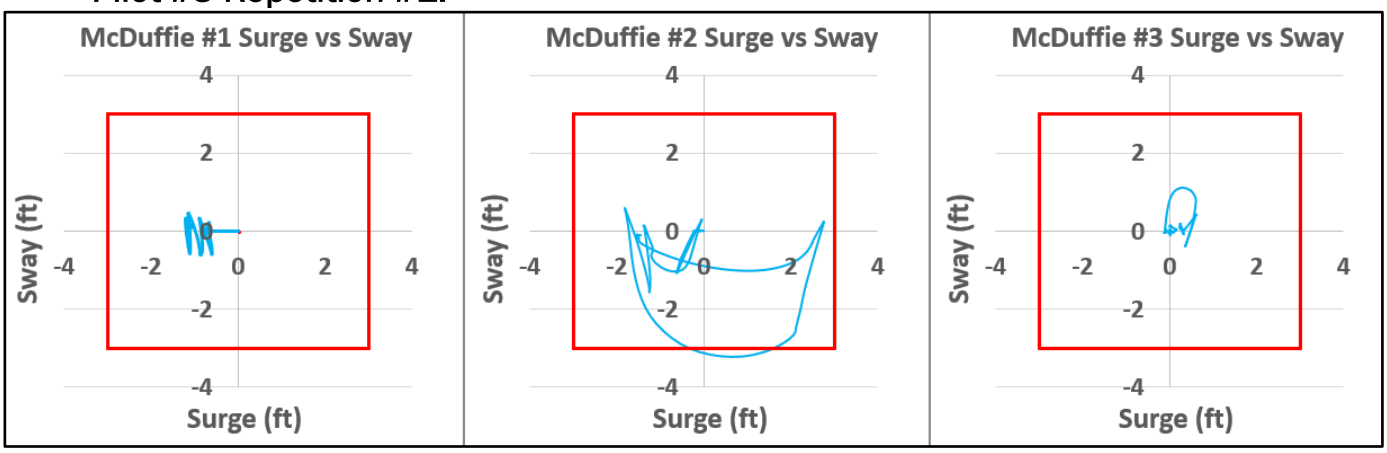
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	296	4.2	-1.2	-0.6	301	4.5	2.8	-3.2	260	5	0.6	1.1
4	335	5.4	4.4	-3.4	340	5.6	4.3	-3.3	293	5.6	0.5	1.8

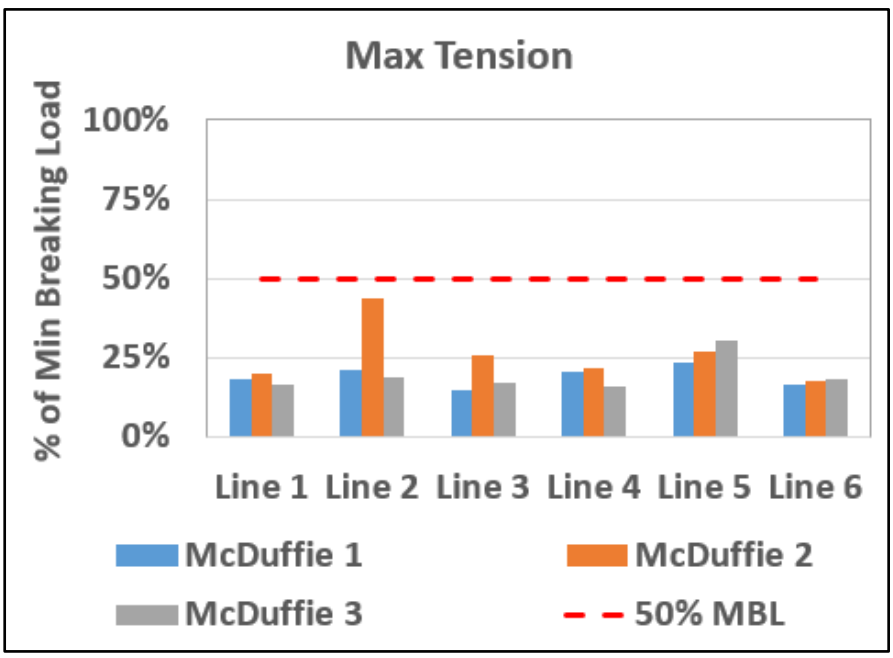
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	YES	McDuffie #2
4	YES	YES	McDuffie #1 & #2

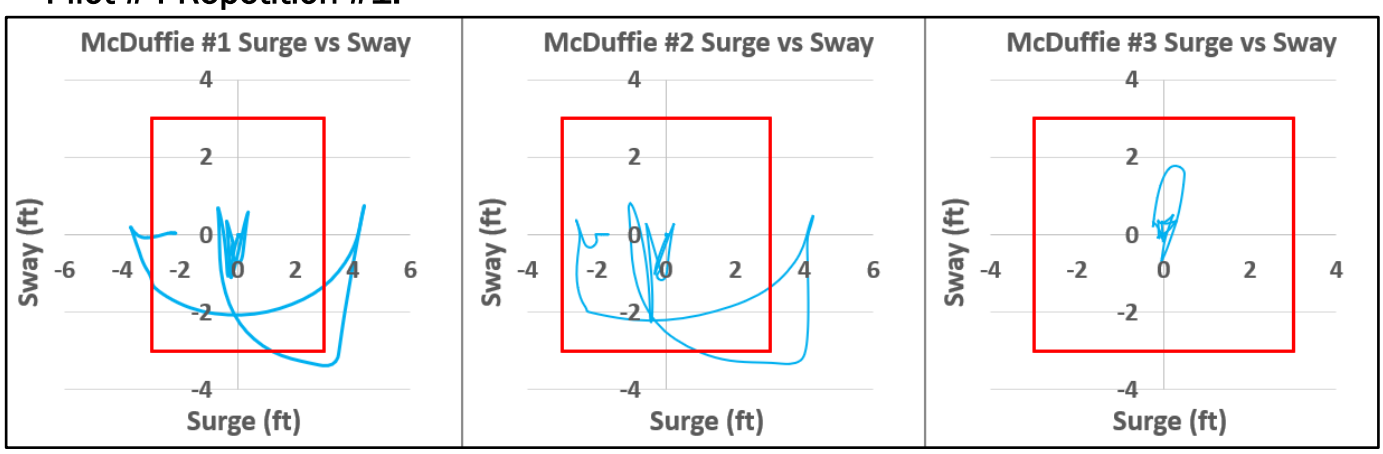
Informational Graphs Plate 16

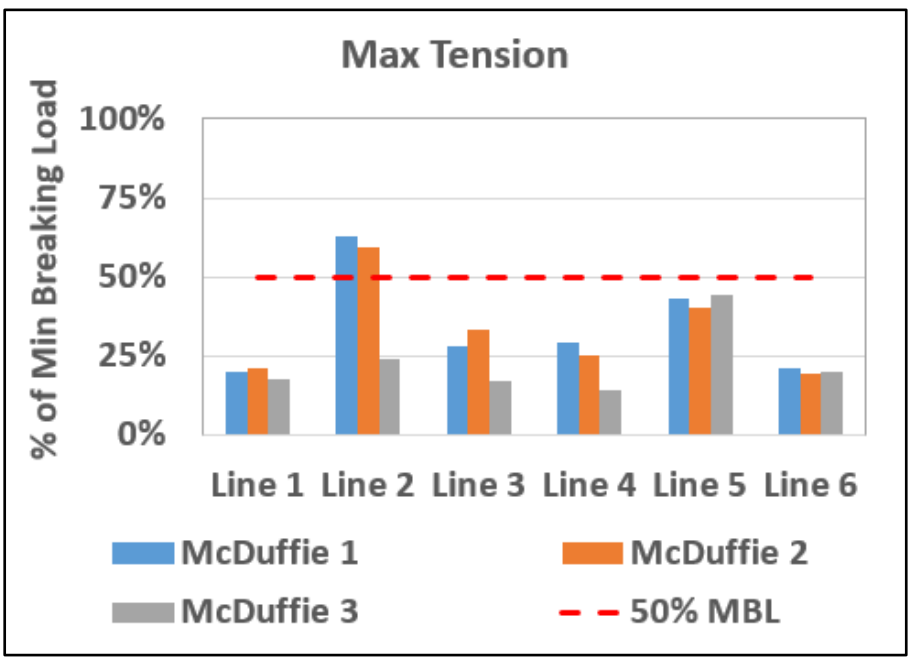
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





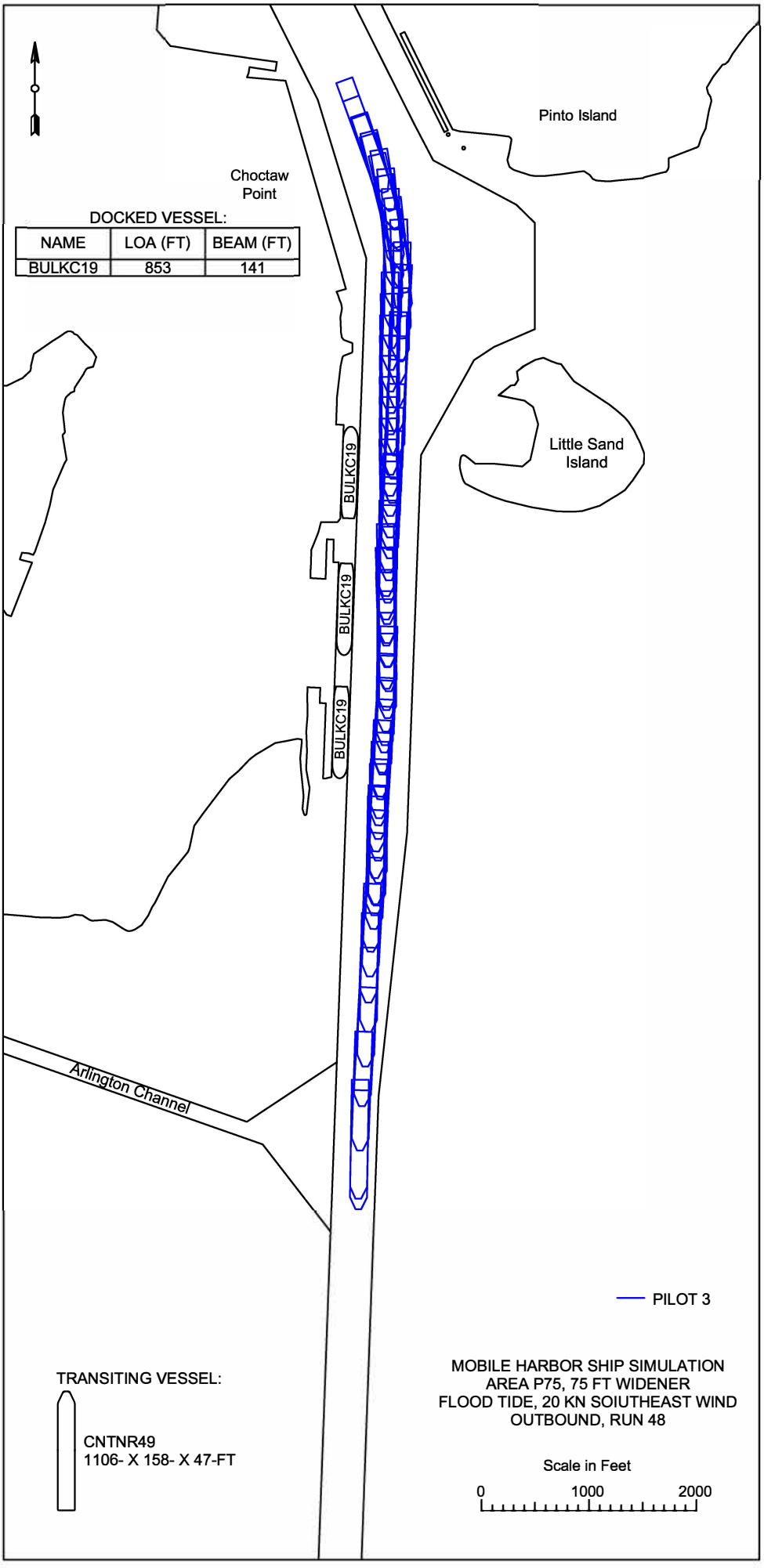

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P75, 75 FT WIDENER
FLOOD TIDE, 20 KN SOIUTHEAST WIND
OUTBOUND, RUN 48
Scale in Feet
0
1000
2000

Plate 17

Informational Sheet Plate 17

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
48	P75	Outbound	Flood	20 knots SE	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	I don't like the fact that when outbound, I only have a little over a ship length to come out of the widened area to return to the centerline. This may cause some pilots to move to the west too soon and put the ship at McDuffie 1 in danger.	Winches were not released.	2	3
3	A few effects of only passing one ship at McDuffie. Still able to stay away from it, but the 100 ft. widener would be nice.	Only docked vessel at McDuffie #2.	2	2

McDuffie Information:

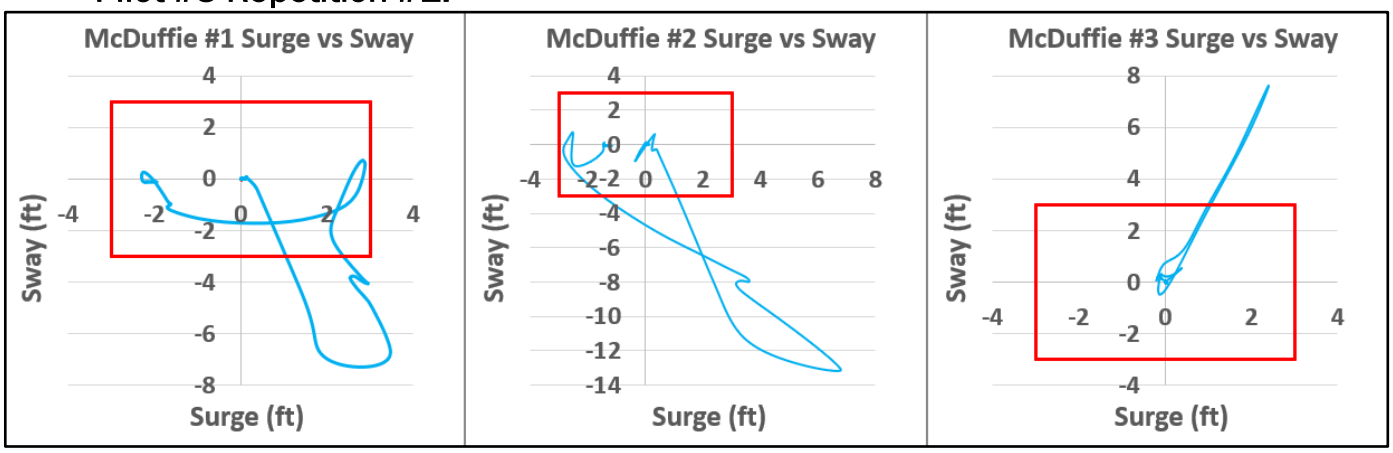
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	251	4.1	3.5	-7.3	242	4.0	6.8	-13.2	214	4.1	2.4	7.6
3	-	-			239	4.6	5.6	-5.2	-	-		

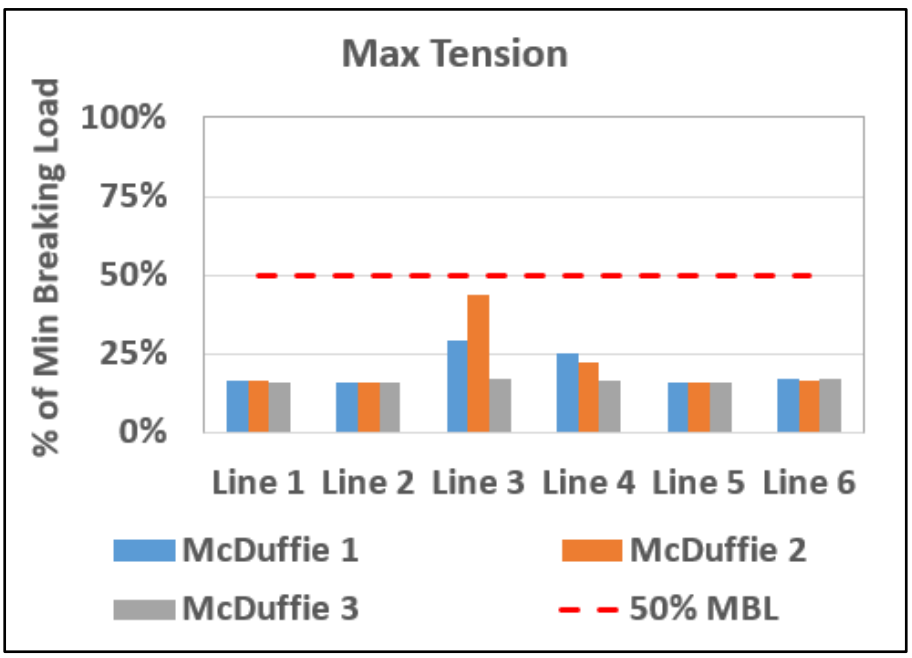
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	YES	McDuffie #1, #2, & #3
3	YES	YES	McDuffie #2

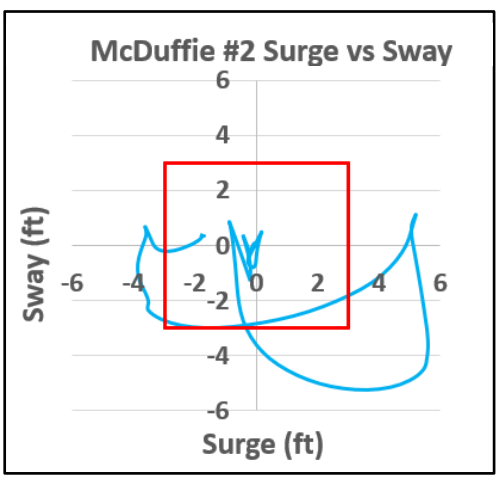
Informational Graphs Plate 17

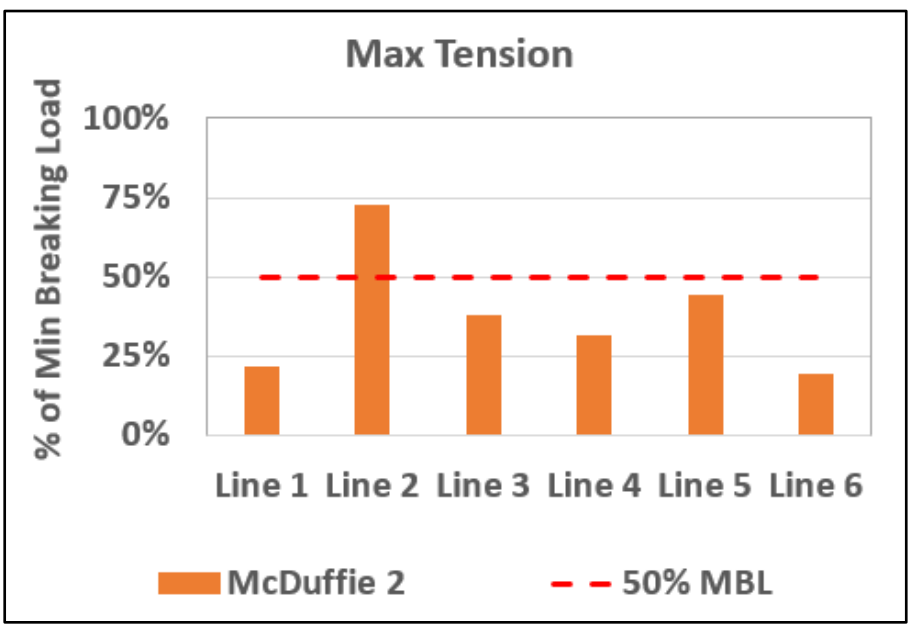
Pilot #3 Repetition #1:





Pilot #3 Repetition #2:





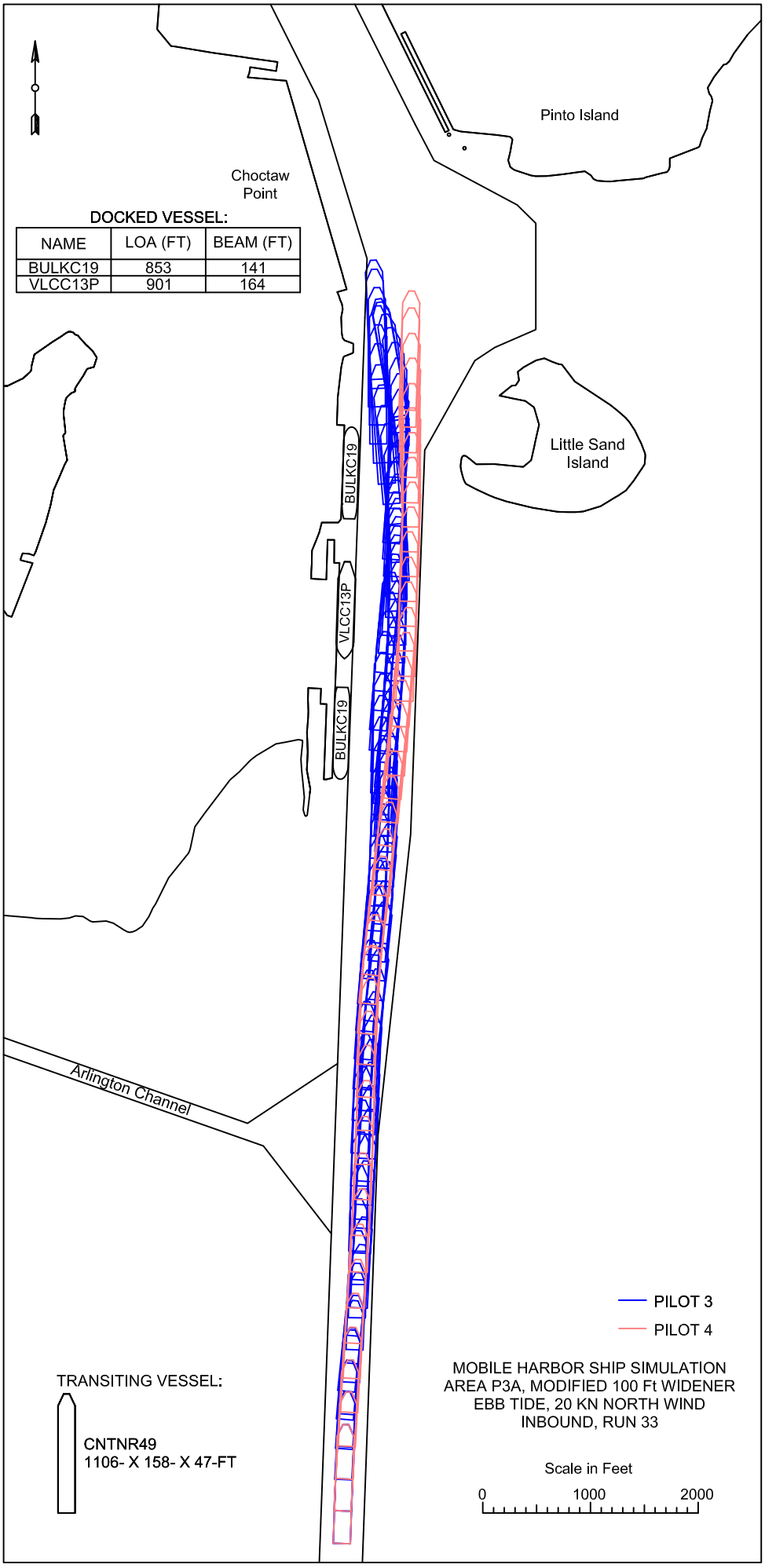

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
EBB TIDE, 20 KN NORTH WIND
INBOUND, RUN 33
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 18

Informational Sheet Plate 18

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
33	P3A	Inbound	Ebb	20 knots N	Zero Bank

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Noticed ship wanted to run to starboard when passing wider section. A bit more speed on this run made steering work out better.		2	1
4	Was able to control speed and heading quite well with minimal to moderate tug use. Aimed for 4.6 knots speed and staying well to the east to edge of channel.		1	1

McDuffie Information:

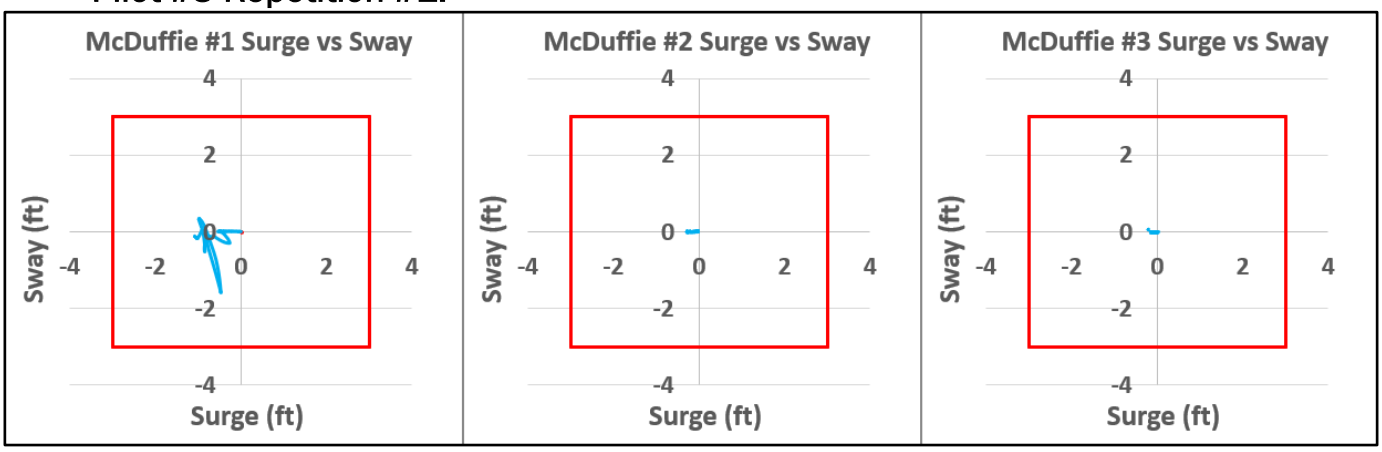
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	209	6	-1.1	-1.6	237	5.6	-0.3	0.0	227	5.7	-0.2	0.1
4	371	6.3	-1.0	-1.0	402	6.7	-0.3	0.0	409	6.7	-0.3	0.1

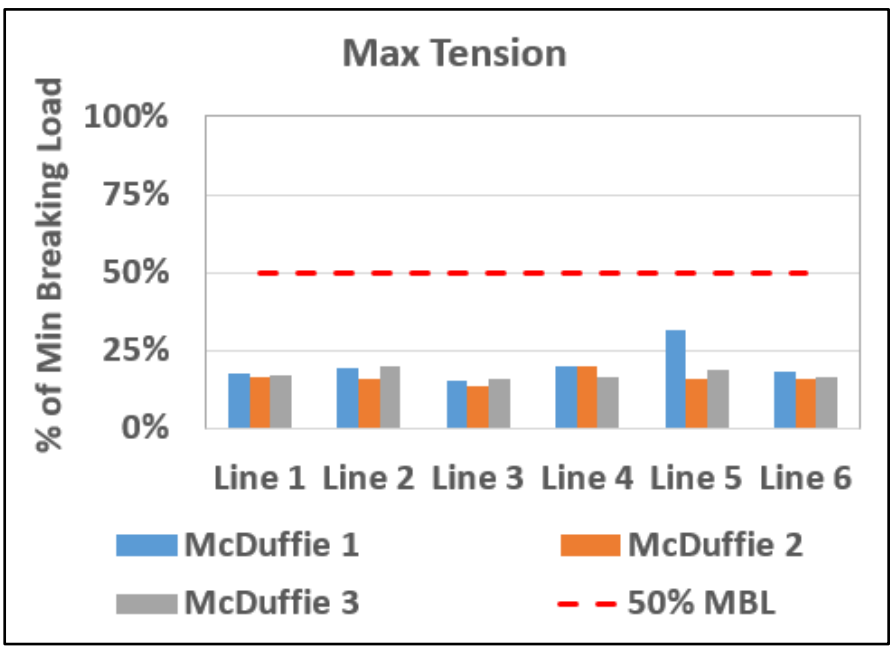
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

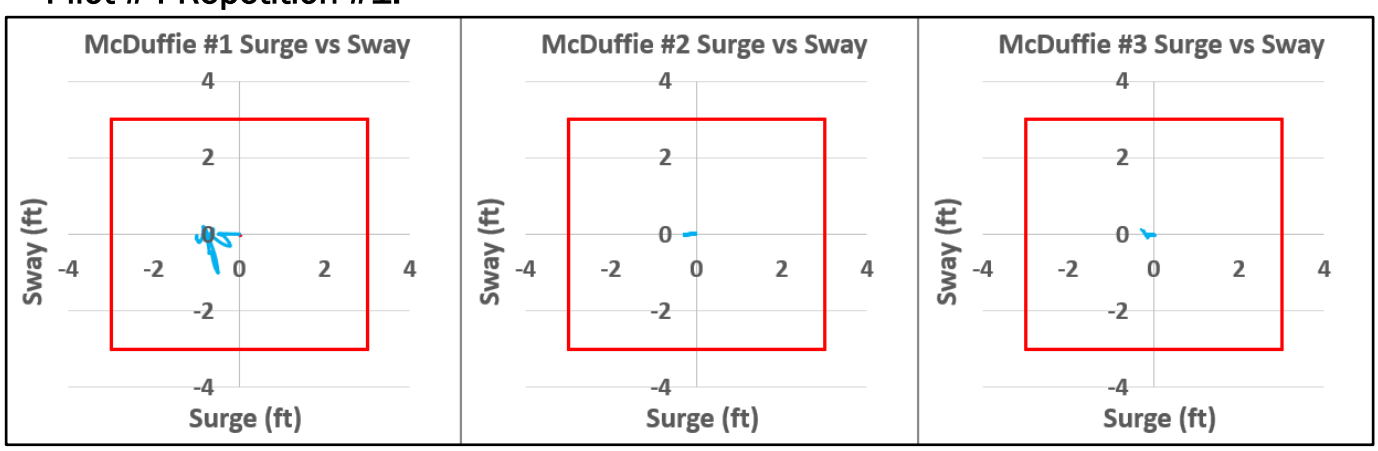
Informational Graphs Plate 18

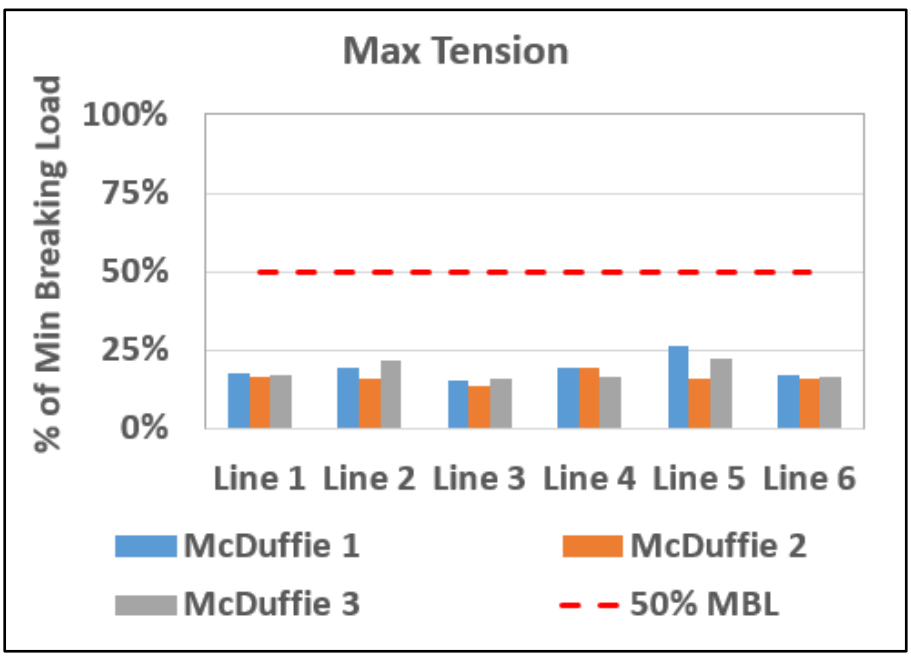
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





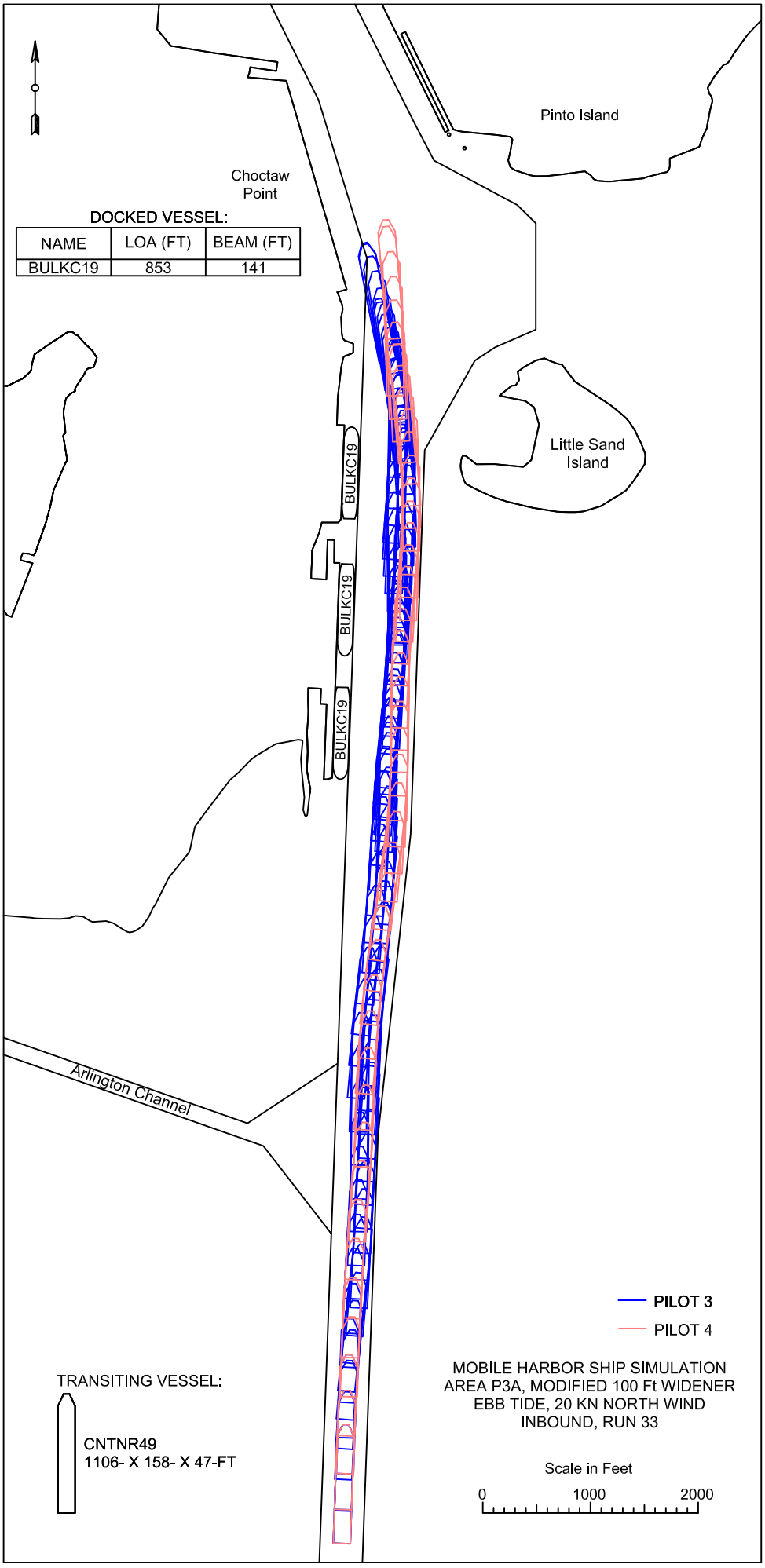

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
EBB TIDE, 20 KN NORTH WIND
INBOUND, RUN 33
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 18B

Informational Sheet Plate 18B

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
33	P3A	Inbound	Ebb	20 knots N	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	With being able to go east more, I think we are more prone to maneuver at a slower speed without over working the tug or ship engines. Safer.		1	1
4	Was able to make approach to pass ships easier with 100 ft. widener. Less drastic angle needed to make to set up. Minimal to moderate tug use to maintain heading and speed.		1	1

McDuffie Information:

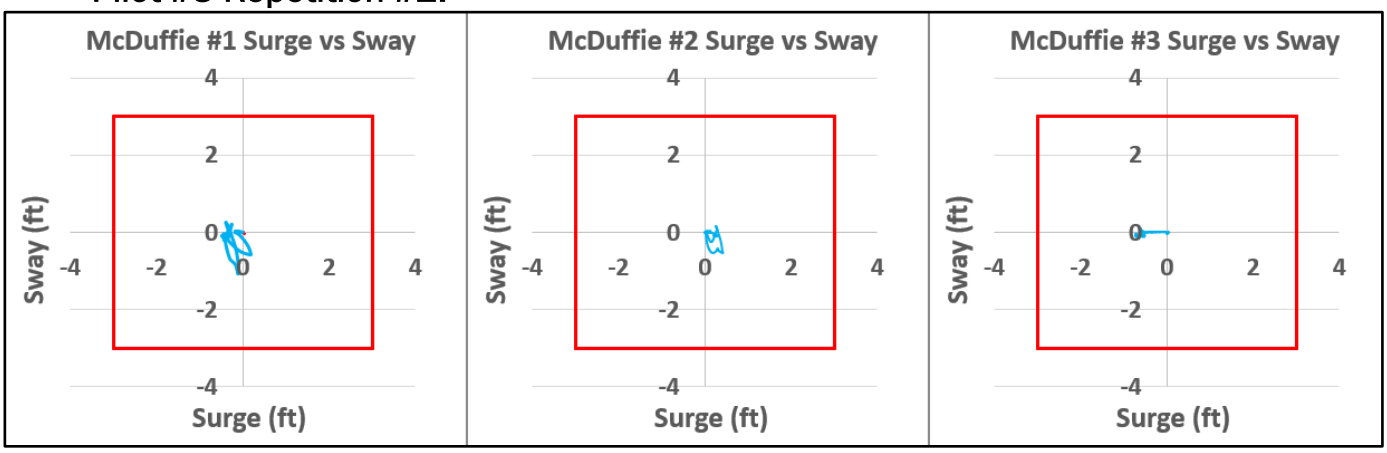
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	282	6.2	-0.5	-1.1	349	6	0.4	-0.5	354	5.5	-0.7	-0.1
4	360	6.3	-0.9	-0.6	390	6.1	0.2	-0.7	402	6.3	-0.6	-0.2

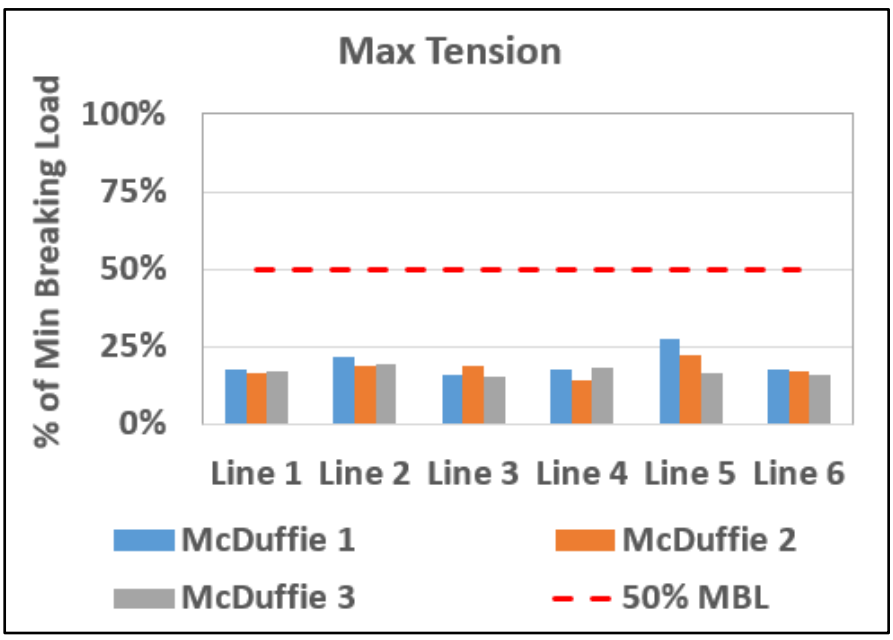
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

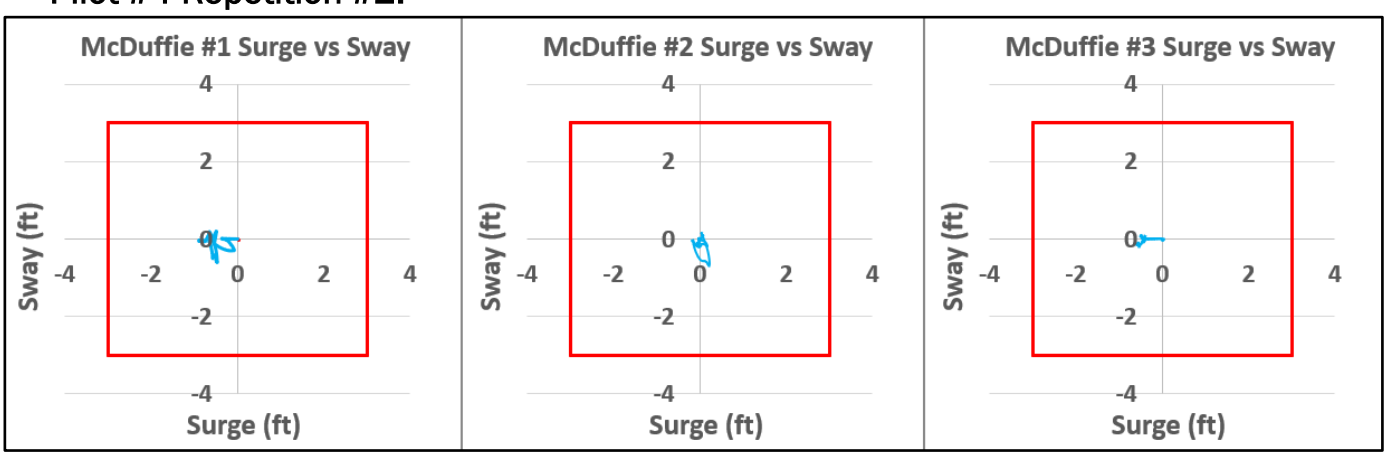
Informational Graphs Plate 18B

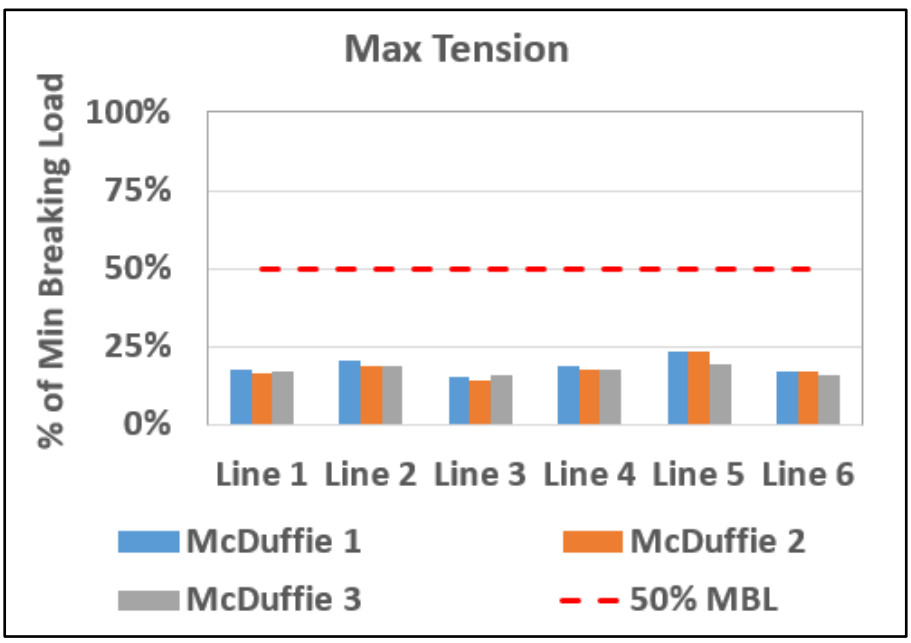
Pilot #3 Repetition #2:





Pilot #4 Repetition #2:





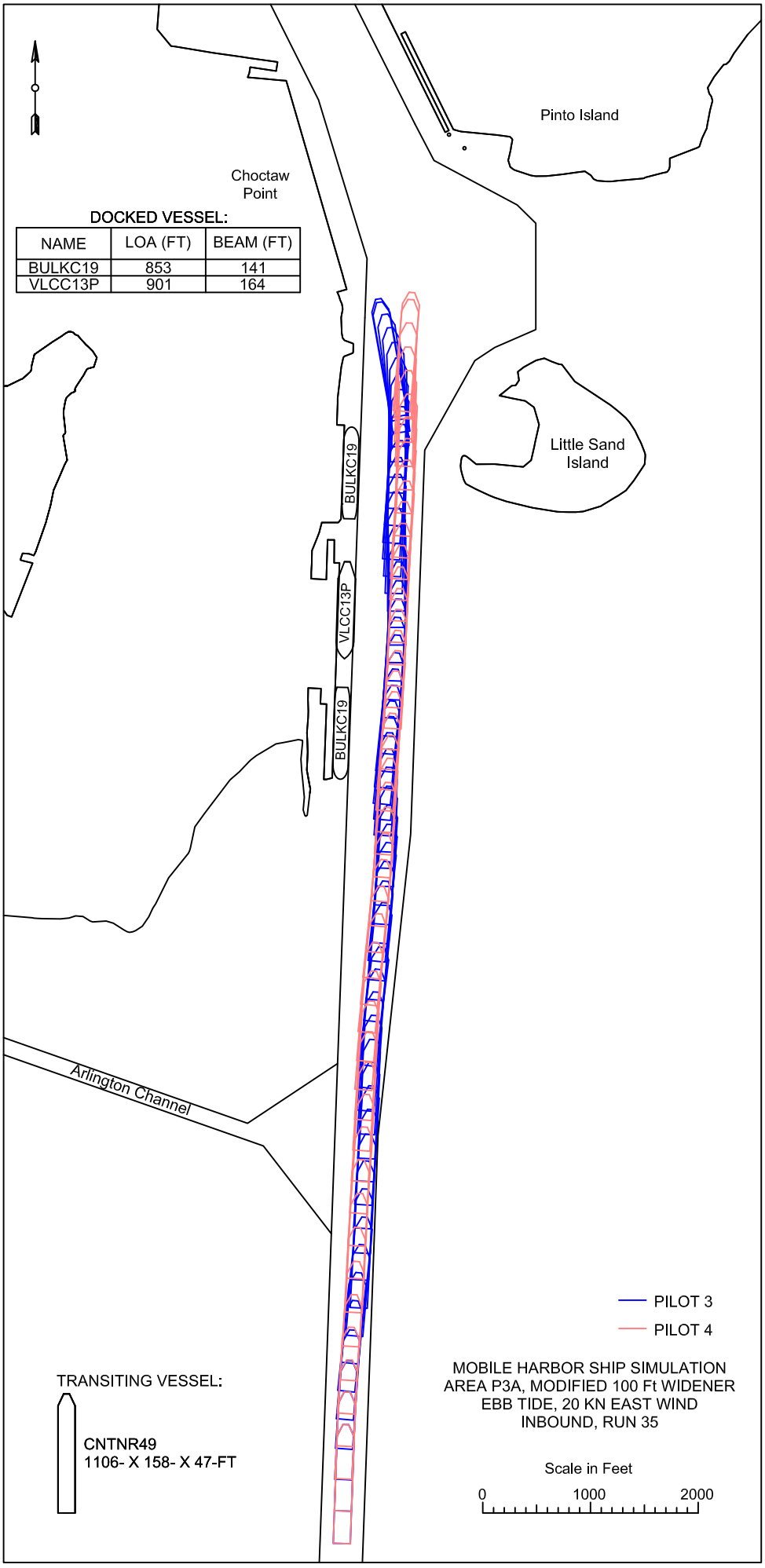

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
EBB TIDE, 20 KN EAST WIND
INBOUND, RUN 35
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 19

Informational Sheet Plate 19

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
35	P3A	Inbound	Ebb	20 knots E	Zero Bank

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Ship seemed to run as expected. I was a little slower than normal but not too much problem.	Winches not released until 10 mins into simulation.	2	1
4	Was not too difficult to control speed and heading. Moderate use of rudder and engine bells.		2	1

McDuffie Information:

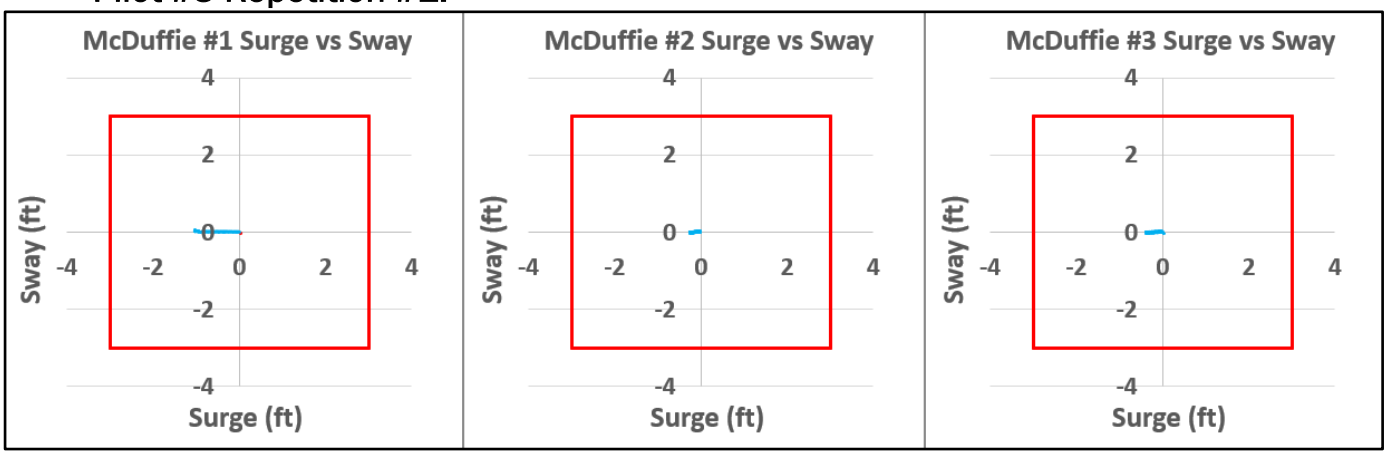
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	288	4.8	-1.0	0.1	295	5.4	-0.3	0.0	283	5.2	-0.4	0.0
4	302	5.7	-0.8	-0.6	313	6	-0.2	0.0	352	6.2	-0.5	0.1

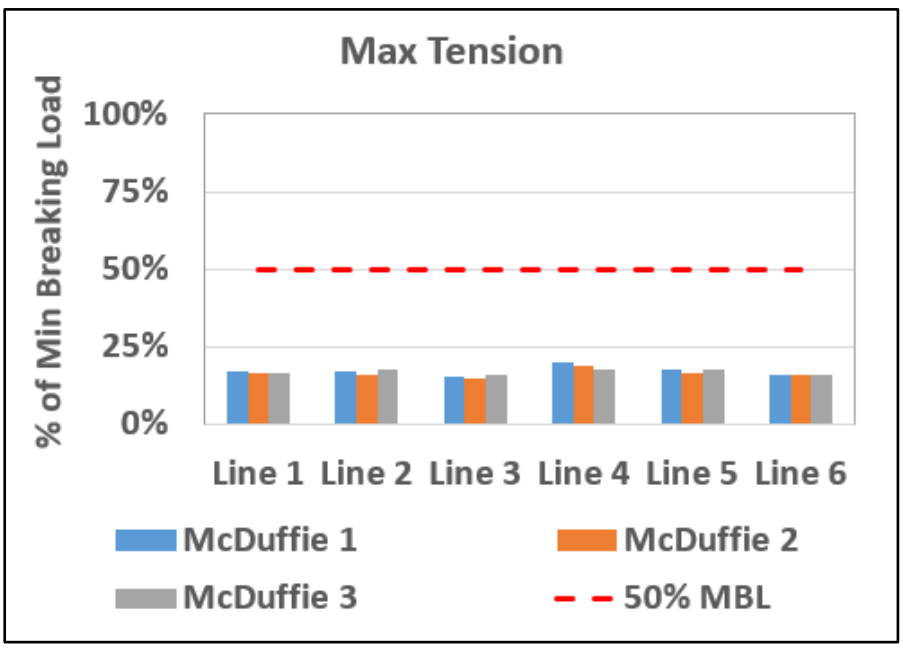
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

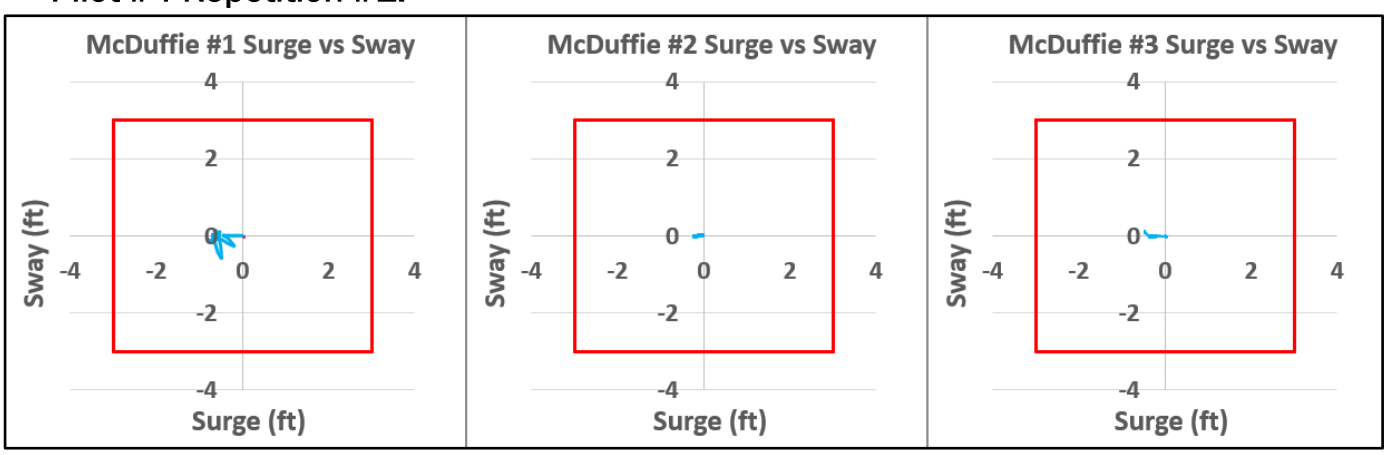
Informational Graphs Plate 19

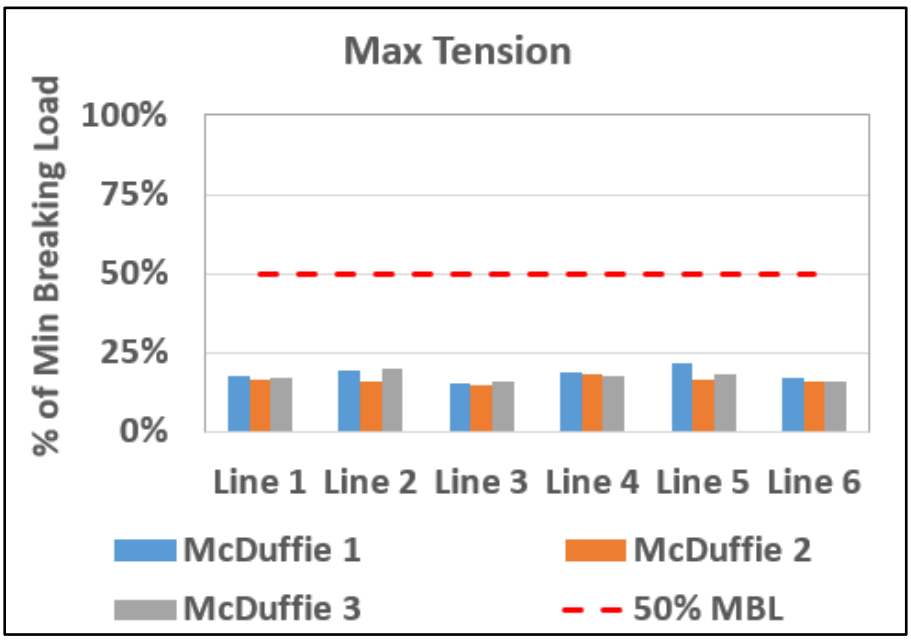
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





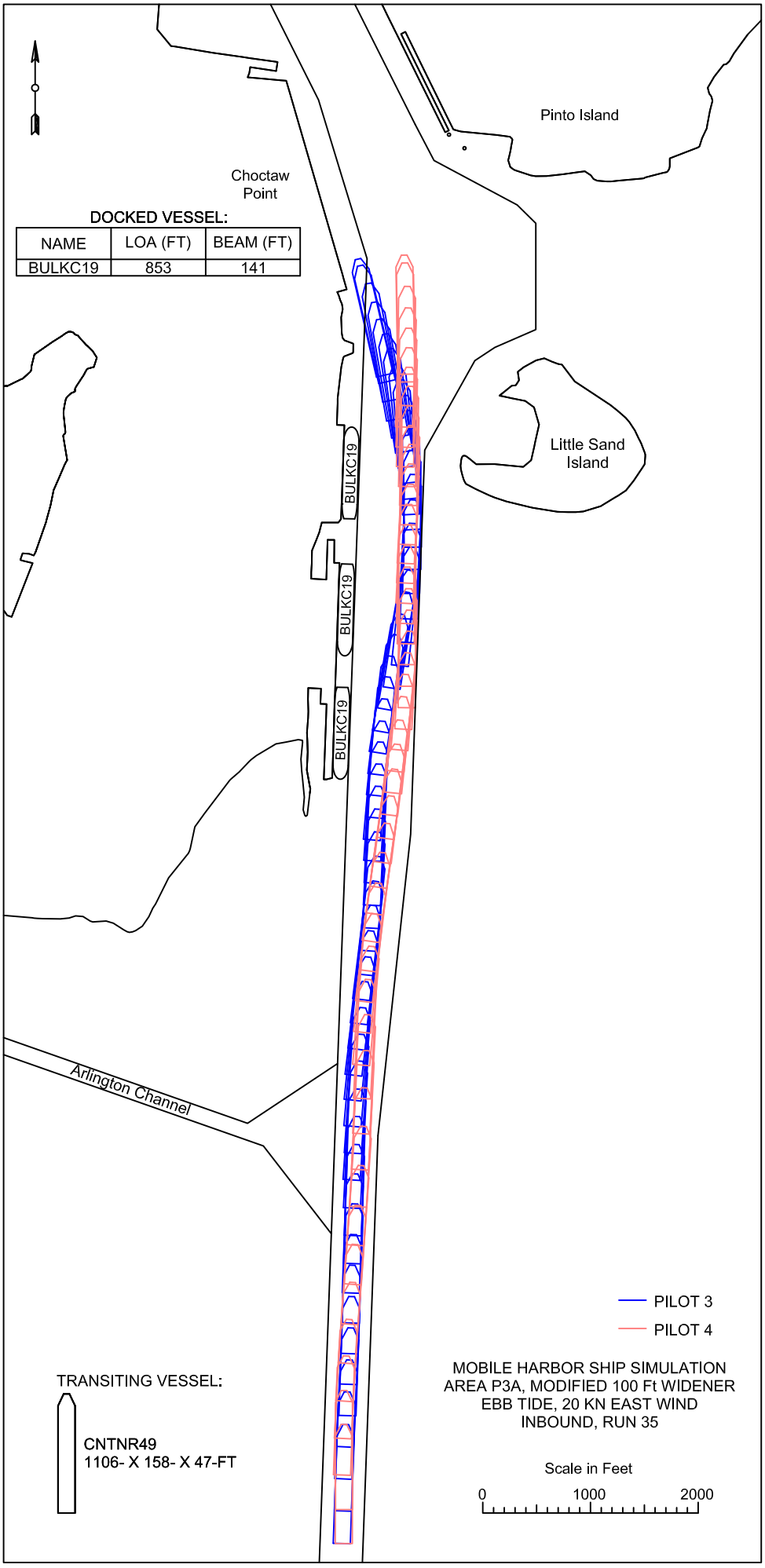

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
EBB TIDE, 20 KN EAST WIND
INBOUND, RUN 35
Scale in Feet
0
1000
2000

Plate 19B

Informational Sheet Plate 19B

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
35	P3A	Inbound	Ebb	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Good run. A little more tug work, but it went well.		1	1
4	Was able to control vessel heading and speed with minimal to moderate tug and engine usage.		2	1

McDuffie Information:

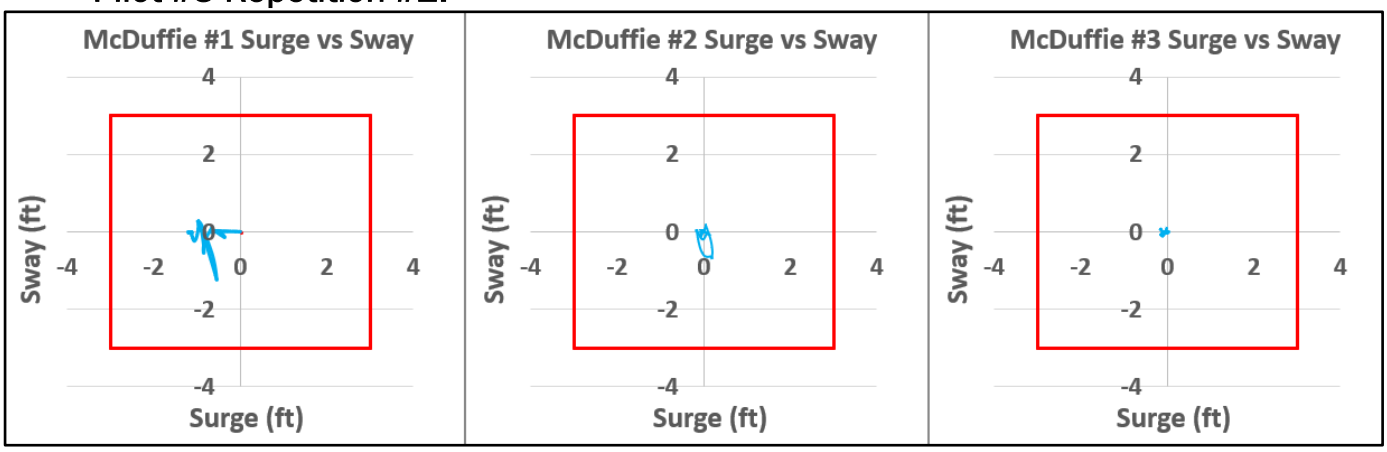
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	221	5.9	1.2	-1.2	395	6.3	0.3	-0.7	407	4.7	0.1	0.2
4	395	5.9	-0.5	-0.6	442	5.8	0.3	-0.4	413	5.6	-0.6	-0.1

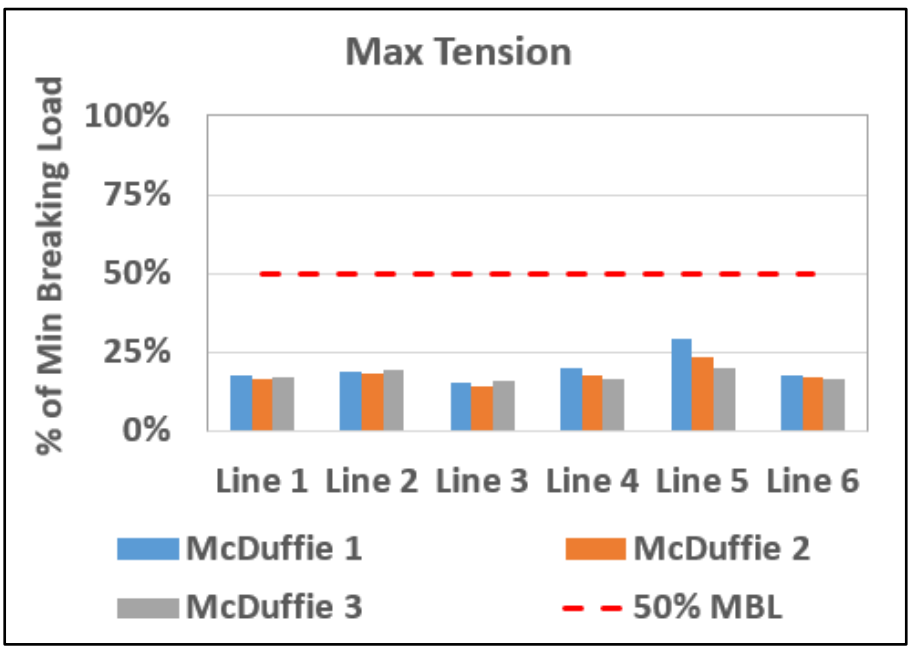
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

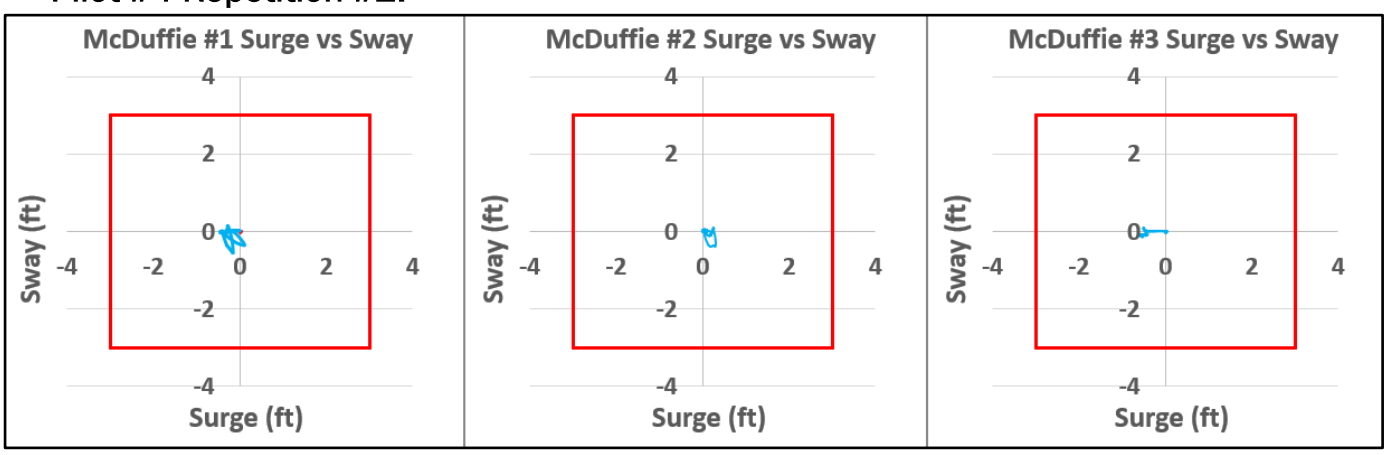
Informational Graphs Plate 19B

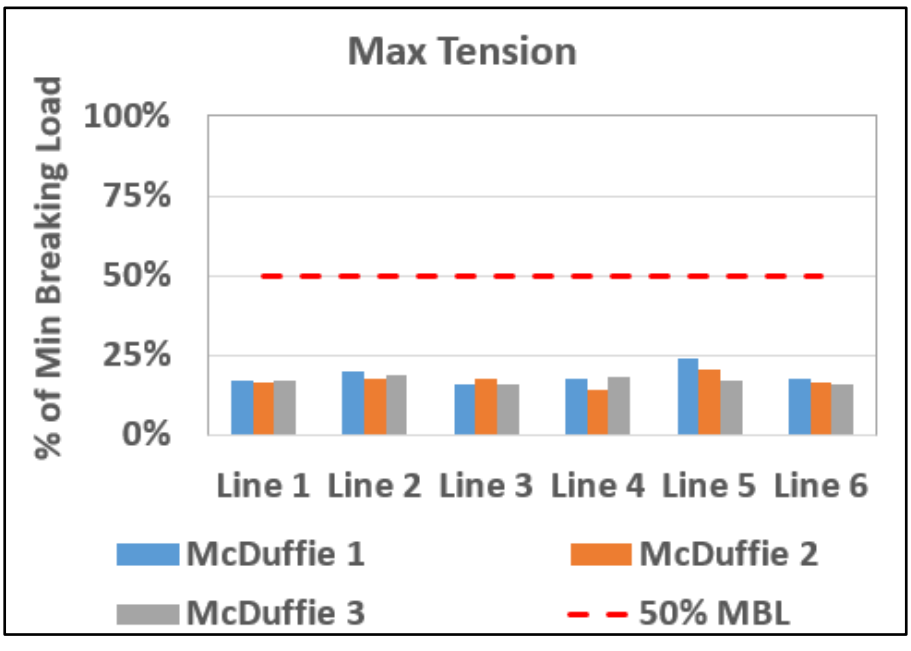
Pilot #3 Repetition #2:





Pilot #4 Repetition #2:





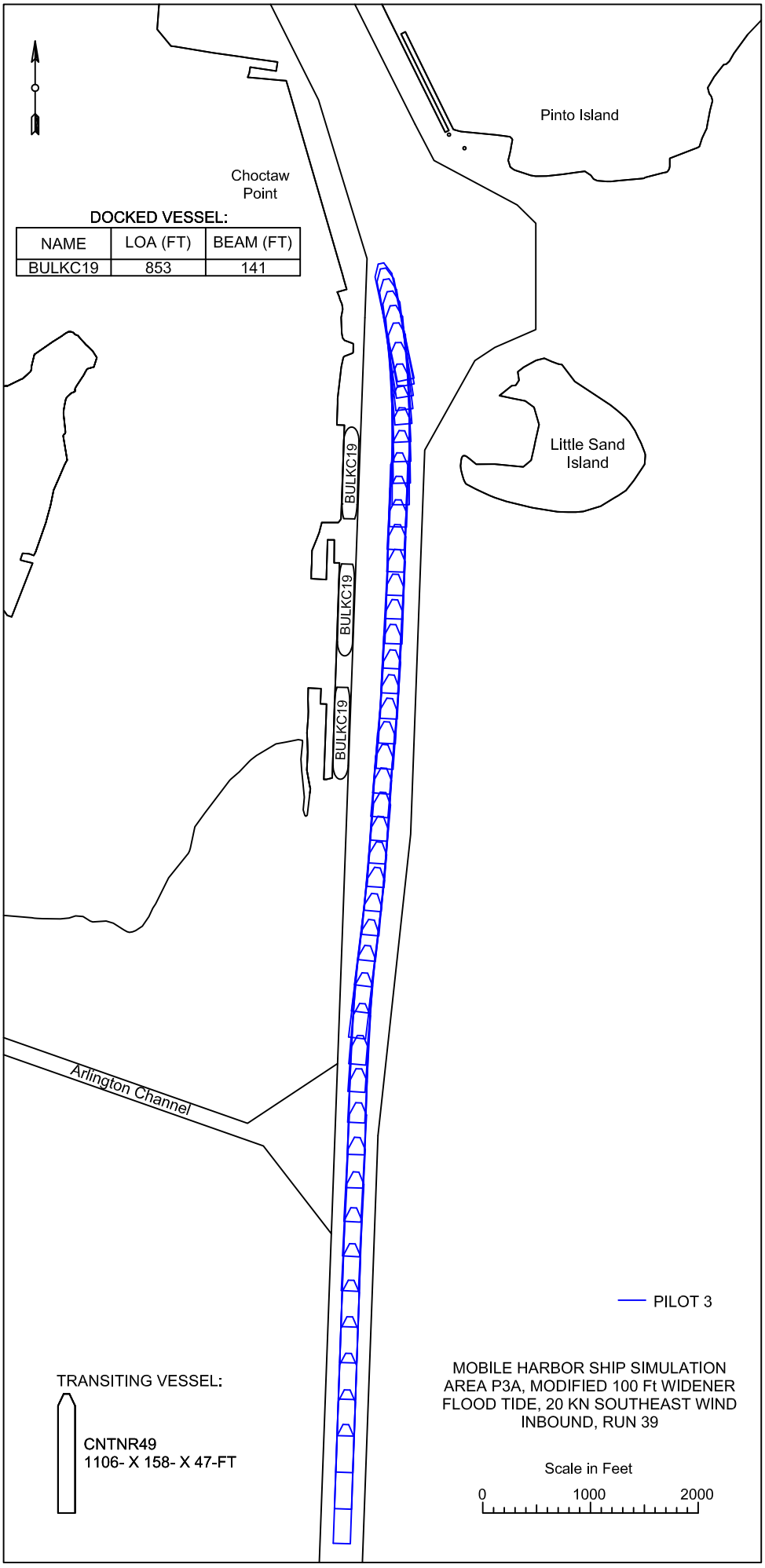

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
FLOOD TIDE, 20 KN SOUTHEAST WIND
INBOUND, RUN 39
Scale in Feet
0
1000
2000

Plate 20

Informational Sheet Plate 20

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
39	P3A	Inbound	Flood	20 knots SE	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Run went well as expected.		2	1

McDuffie Information:

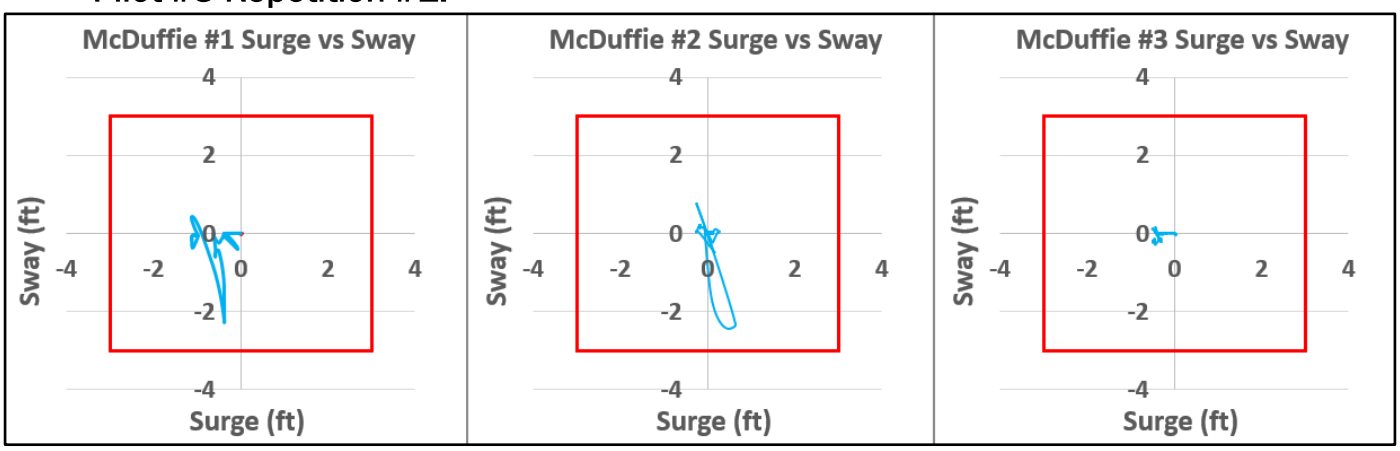
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	270	4.4	-1.1	-2.3	292	4.5	0.6	-2.5	300	4.1	-0.5	-0.3

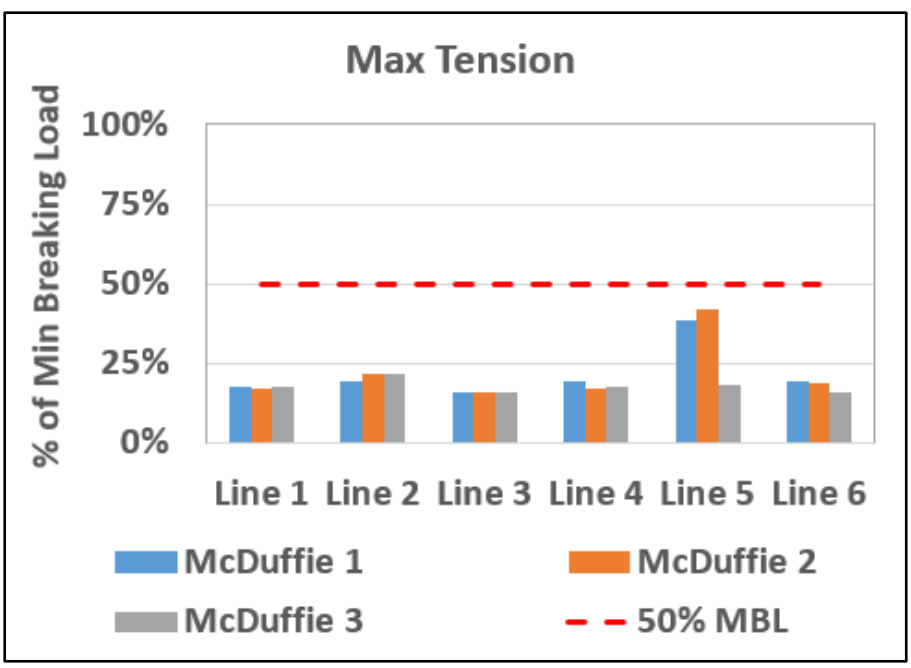
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A

Informational Graphs Plate 20

Pilot #3 Repetition #1:





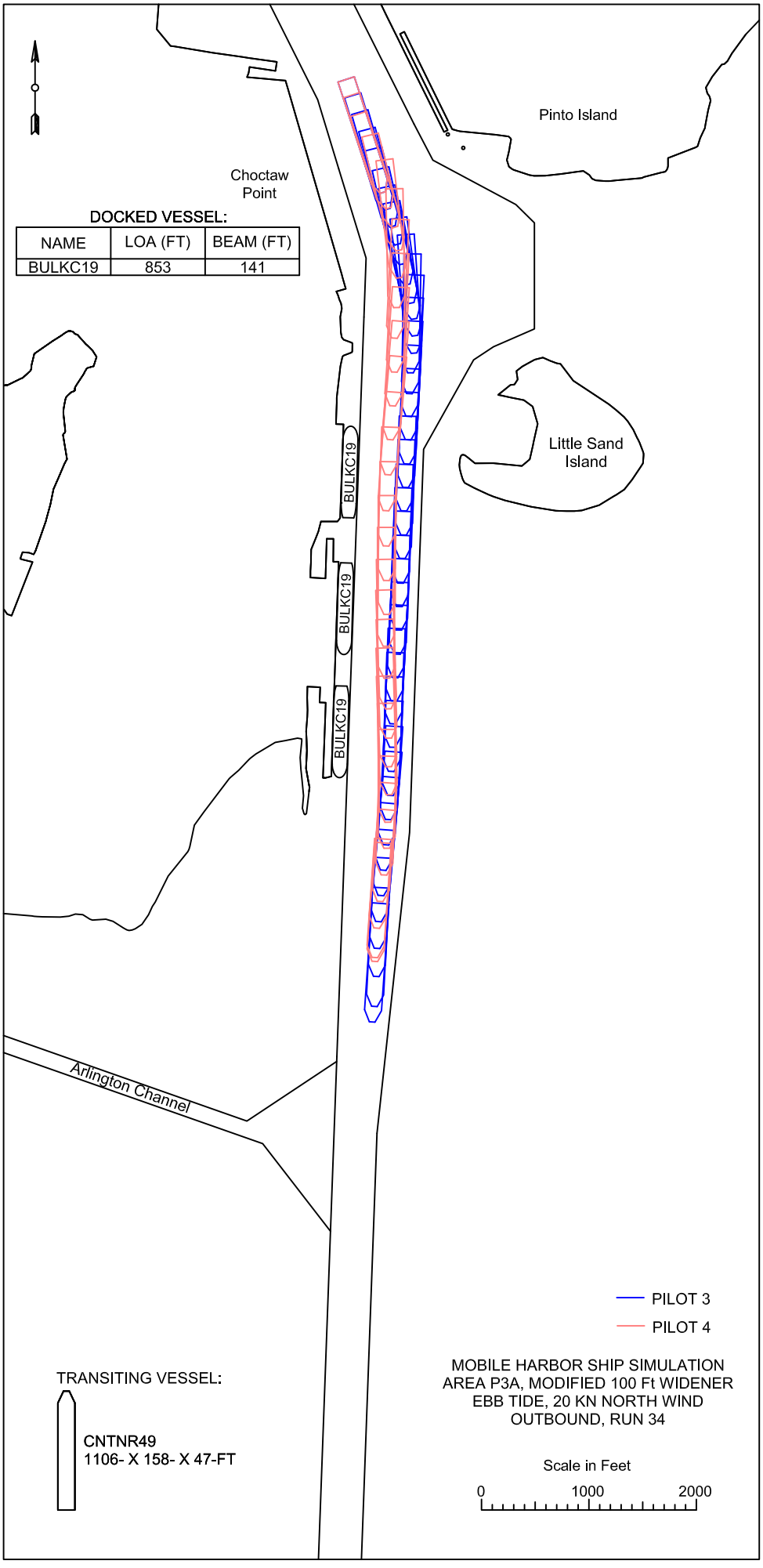

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
EBB TIDE, 20 KN NORTH WIND
OUTBOUND, RUN 34
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 21

Informational Sheet Plate 21

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
34	P3A	Outbound	Ebb	20 knots N	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Run went well. Not much use of tugs, ship responded well, even when put a bit more to the east than normal.		1	1
4	Strong wind and ebb current made it more difficult to control speed. Had to back tug stronger. Heading control was not a problem. Had to stop engine for a while to keep vessel at safer passing speed.		3	1

McDuffie Information:

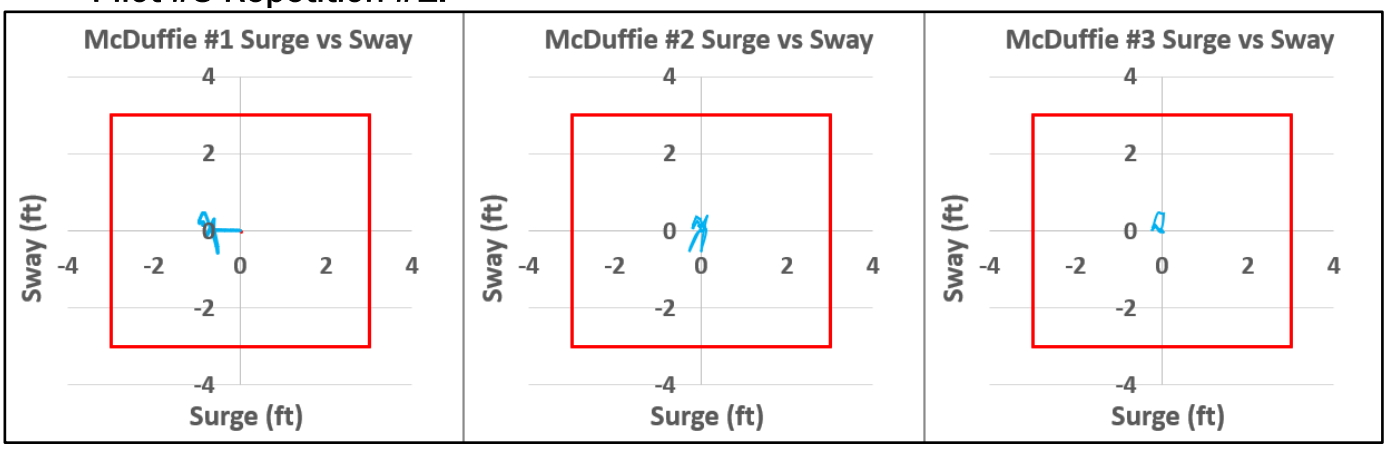
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	340	2.5	-0.9	-0.6	348	2.2	-0.3	-0.5	366	2.1	-0.2	0.5
4	280	3.1	-2.3	-4.3	230	3.6	8.4	-15.4	210	4.3	-4.1	19.7

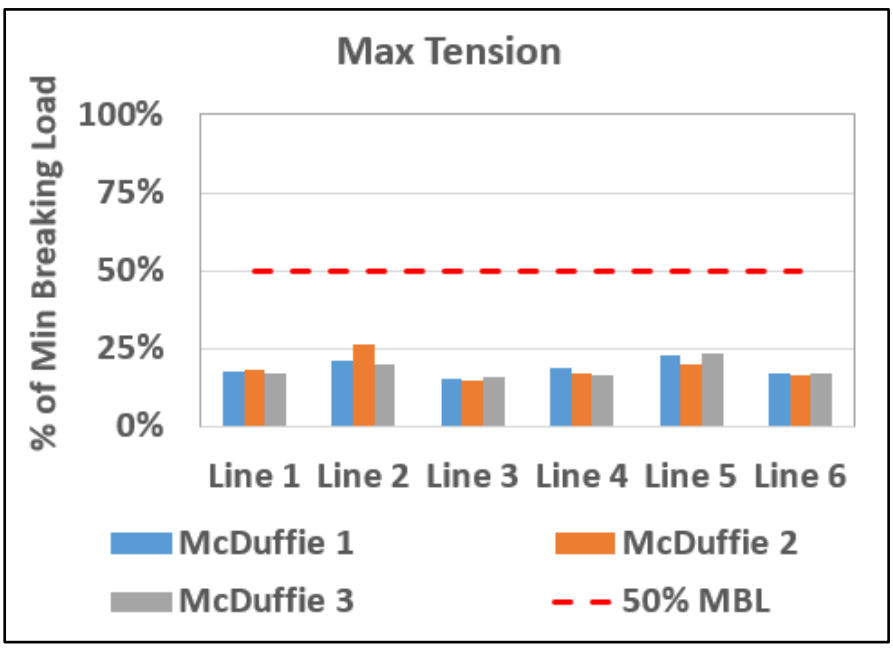
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	YES	YES	McDuffie #1, #2, & #3

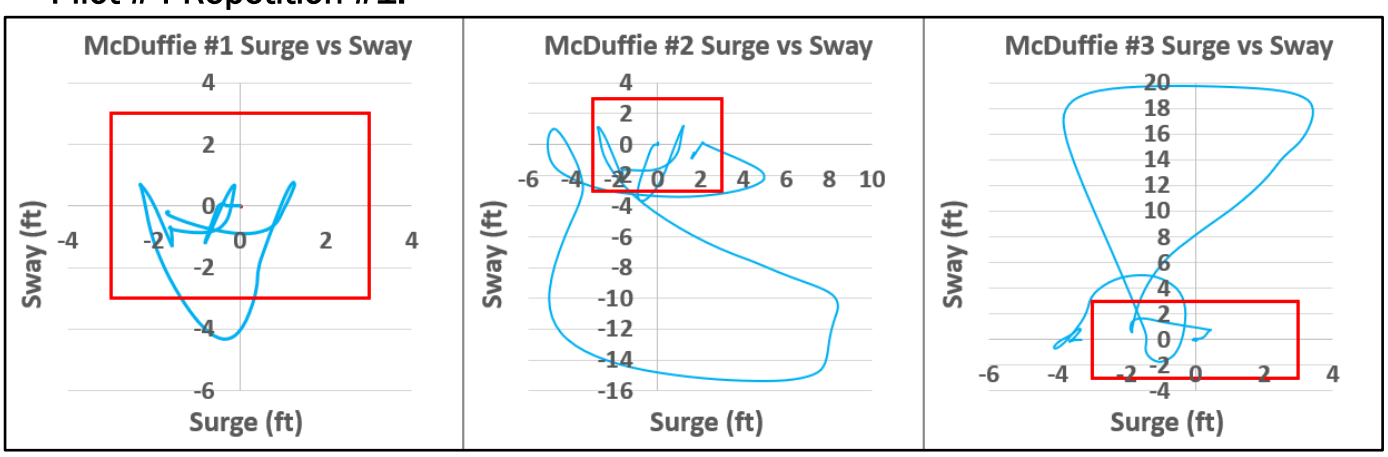
Informational Graphs Plate 21

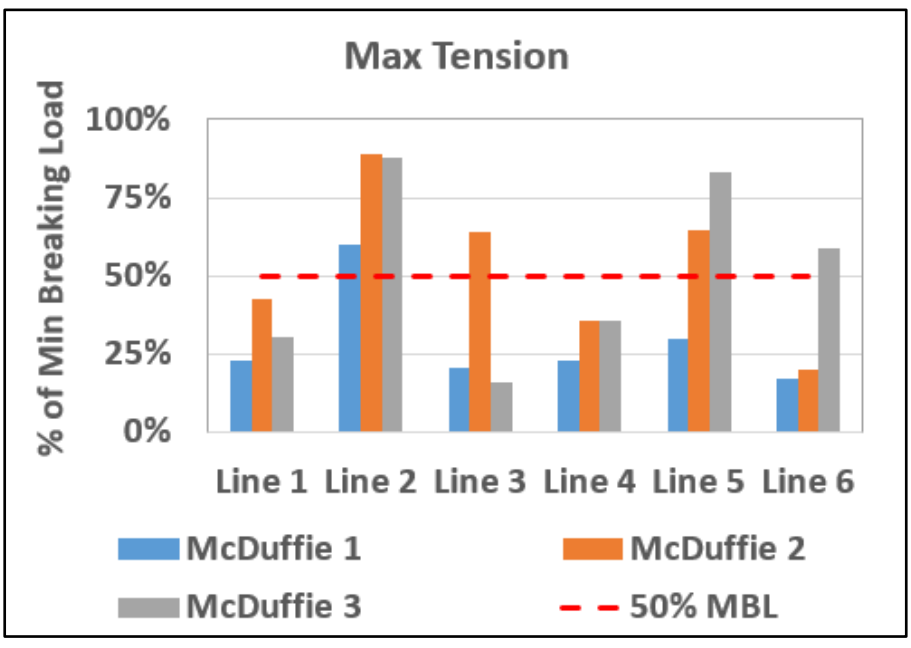
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





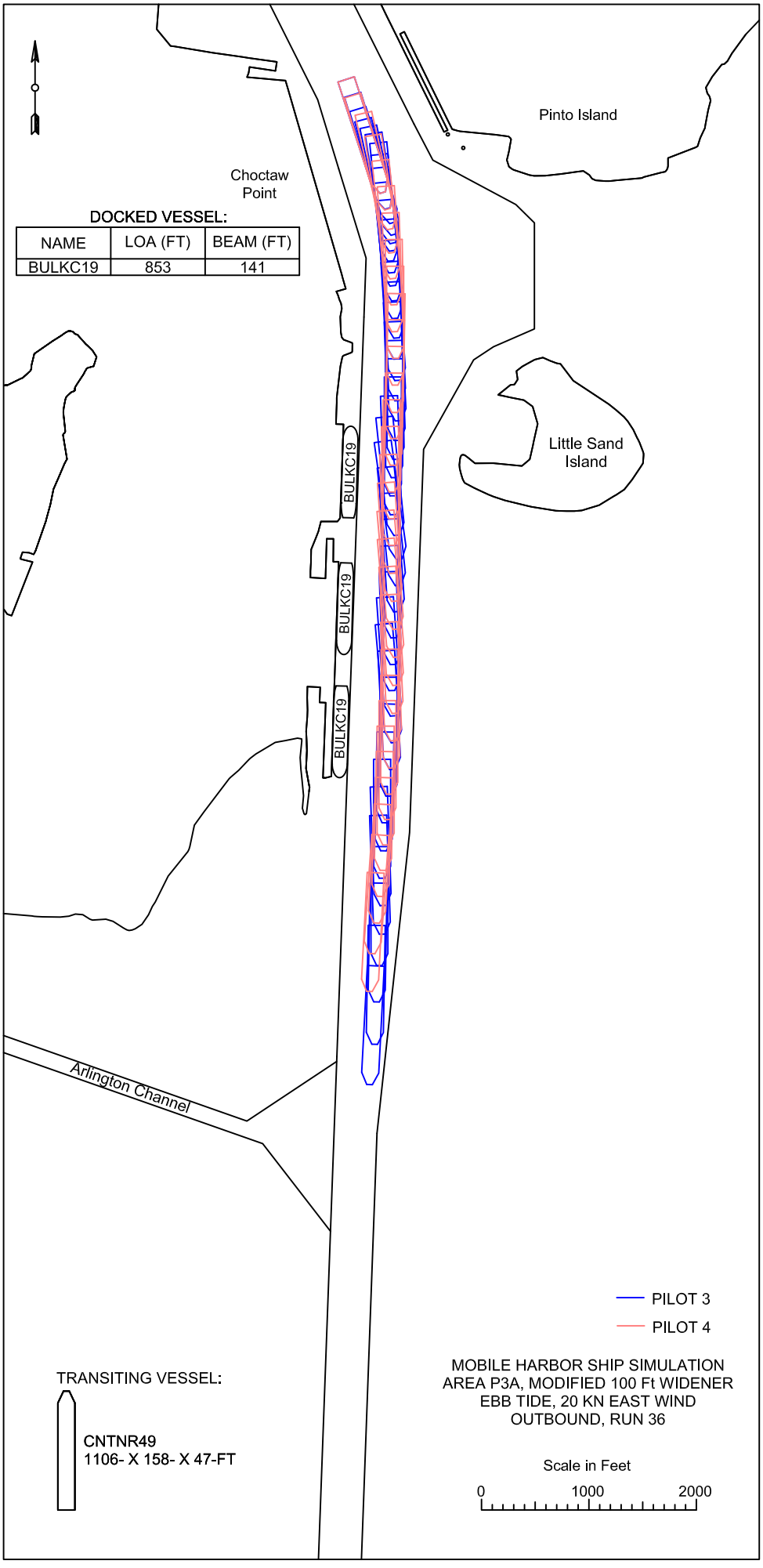

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
EBB TIDE, 20 KN EAST WIND
OUTBOUND, RUN 36
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 22

Informational Sheet Plate 22

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
36	P3A	Outbound	Ebb	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Good run. Tug was key to keep speed down; still be able to keep the ship where it needed to be.		2	1
4	Had to work tug moderately to control speed. Heading control was good.		2	1

McDuffie Information:

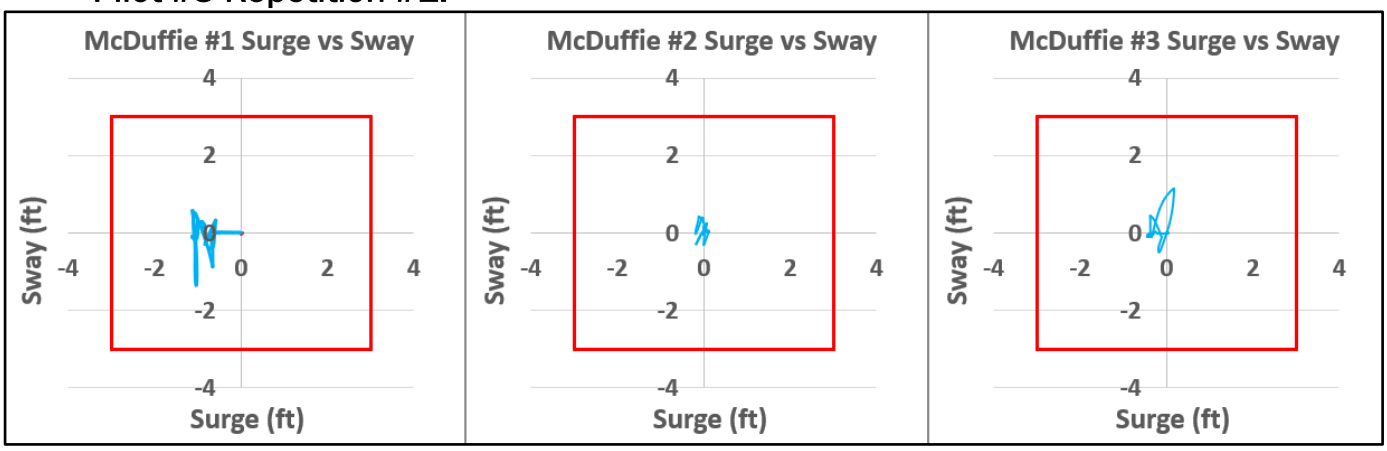
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	294	3.1	-1.1	-1.4	280	2.8	-0.2	0.4	227	2.2	-0.4	1.2
4	305	2.9	-1.3	-0.5	290	3.1	5.1	-5.3	244	3	0.9	1.9

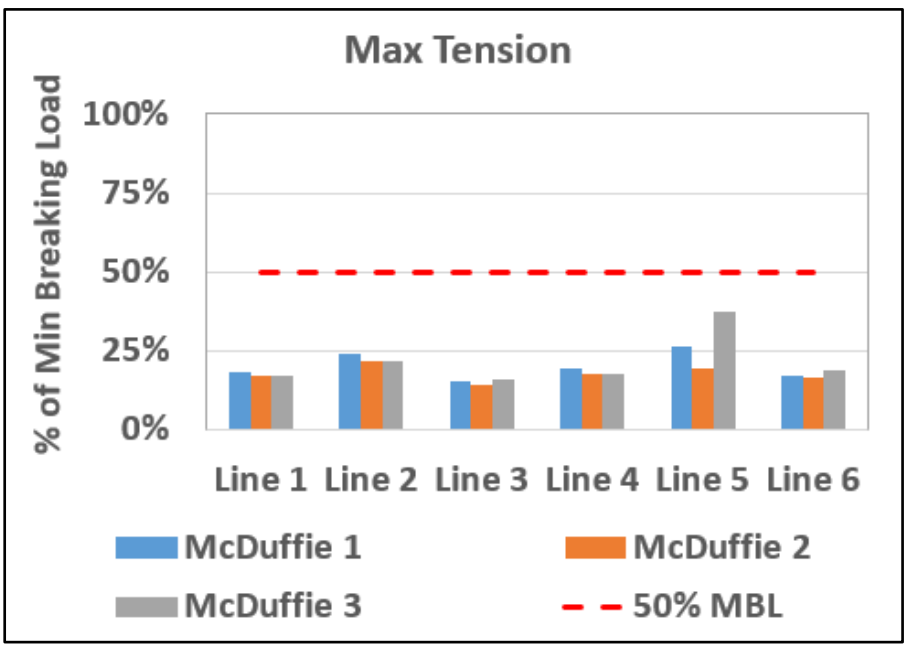
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	YES	YES	McDuffie #2

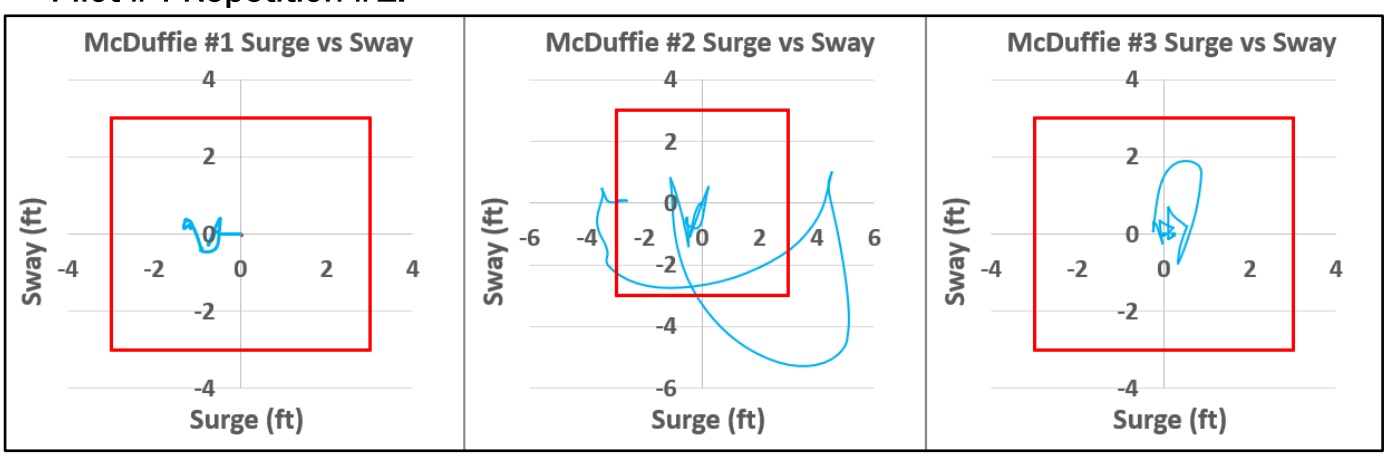
Informational Graphs Plate 22

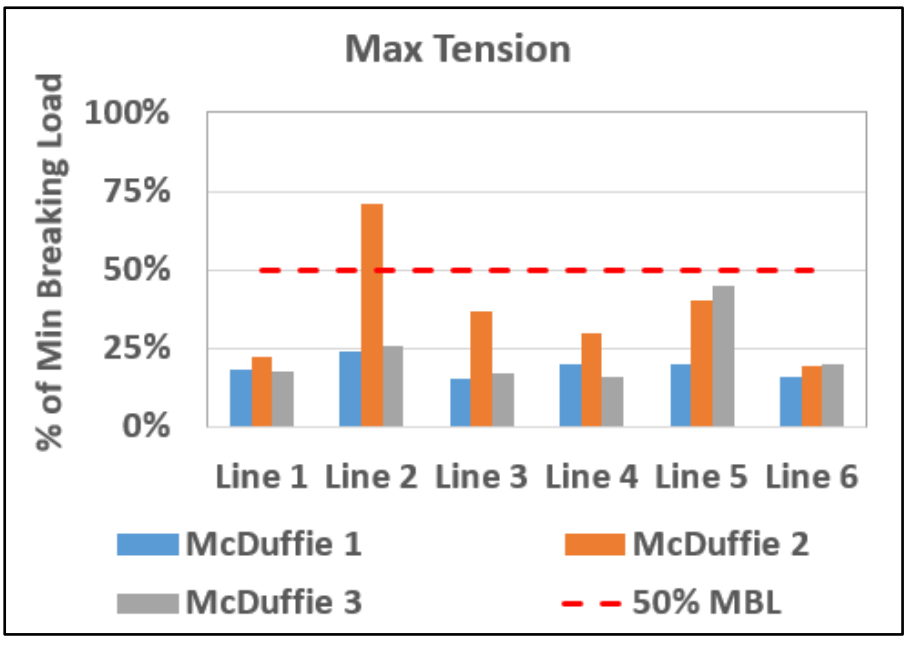
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





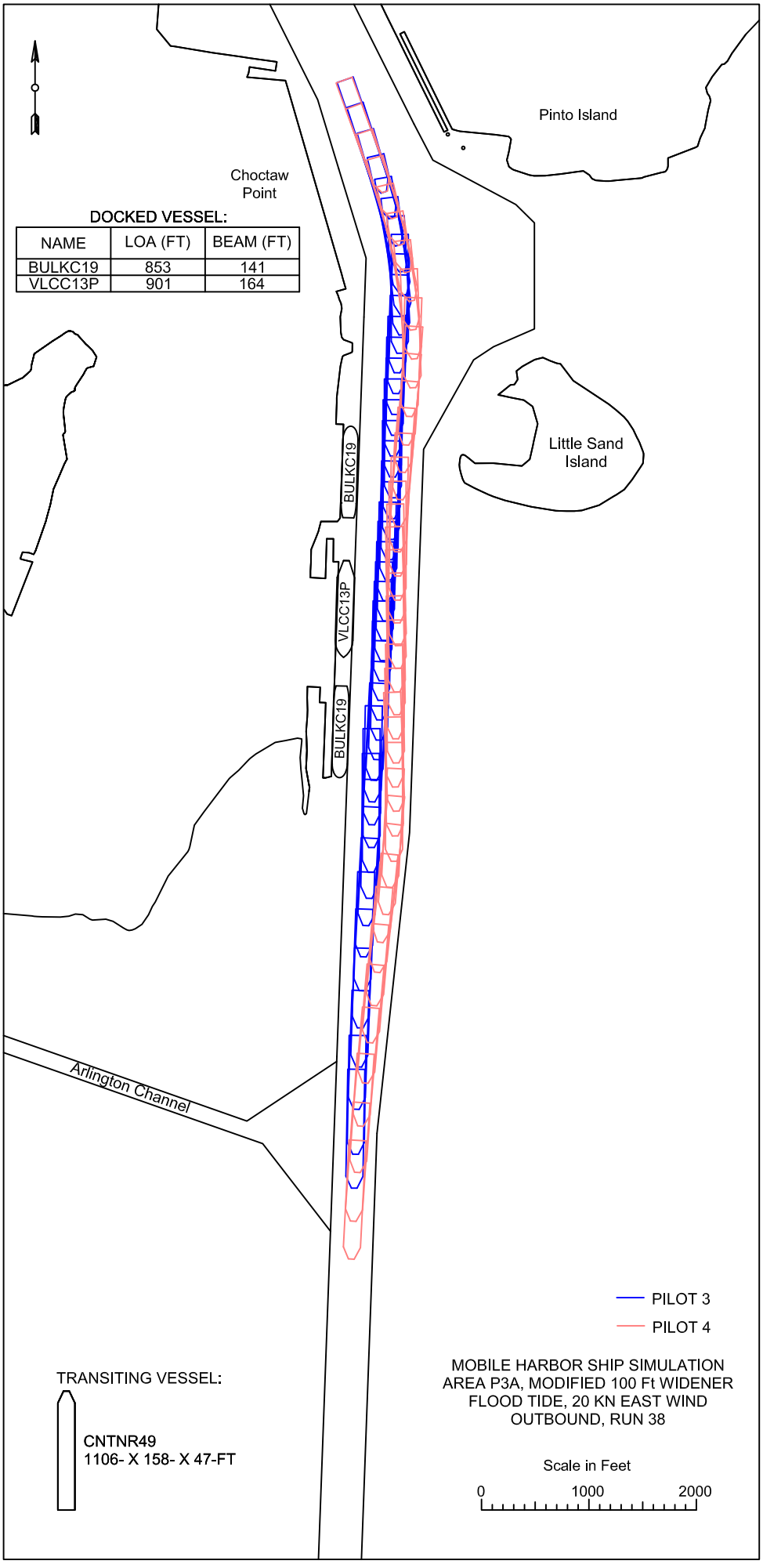

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
VLCC13P | 901 | 164
Little Sand Island
BULKC19
VLCC13P
BULKC19
Arlington Channel
PILOT 3
PILOT 4
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
FLOOD TIDE, 20 KN EAST WIND
OUTBOUND, RUN 38
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
Scale in Feet
0
1000
2000

Plate 23

Informational Sheet Plate 23

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
38	P3A	Outbound	Flood	20 knots E	Zero Bank

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	Ship did well with these conditions. Nice to have room to the east. Tug came in handy at the start. Was needed to pass the moored ships.		2	1
4	Started exercise with 5 knots and going into turn above McDuffie southbound. Had a little difficulty making turn and reducing speed before passing ship at McDuffie #3, but was able to get good control with moderate tug use and get speed down. Sailing from container dock probably wouldn't really get up to 5 knots at that starting spot but good practice exercise.	Winches released approximately 1:45 into simulation	2	2

McDuffie Information:

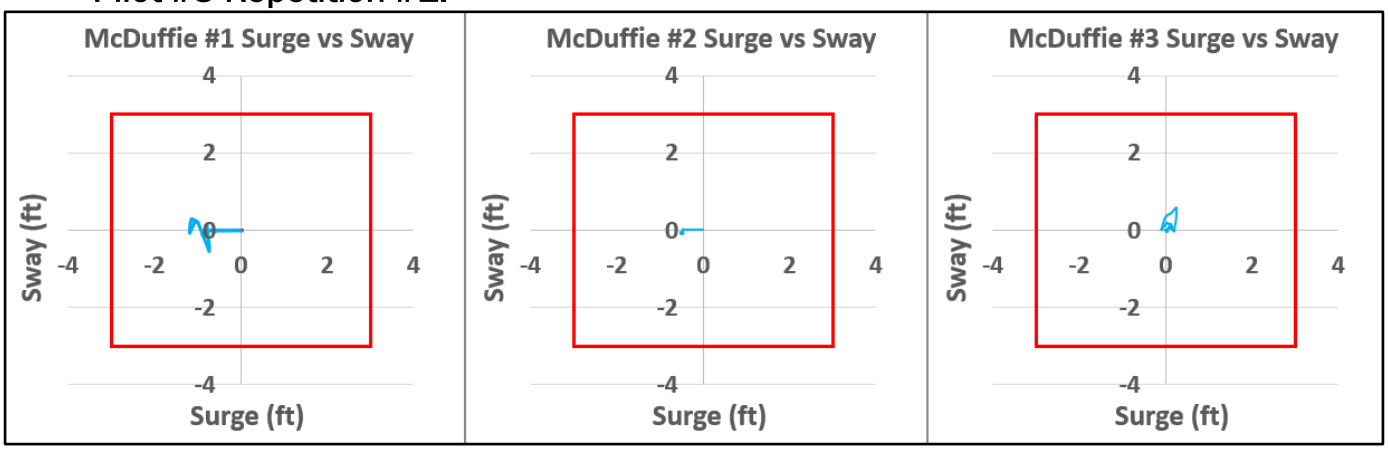
	McDuffie #1: BULKC19				McDuffie #2: VLCC13P				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	175	4.2	-1.2	-0.5	193	3.9	-0.5	-0.1	248	4.1	0.3	0.6
4	348	4.6	-1.0	-0.6	305	4.5	-0.5	0.0	332	4.9	0.3	0.7

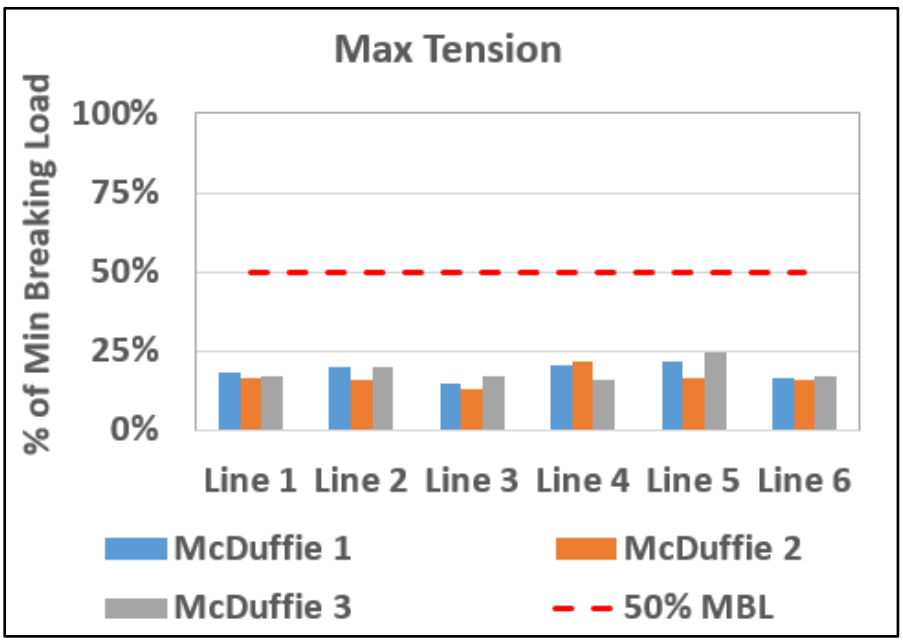
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

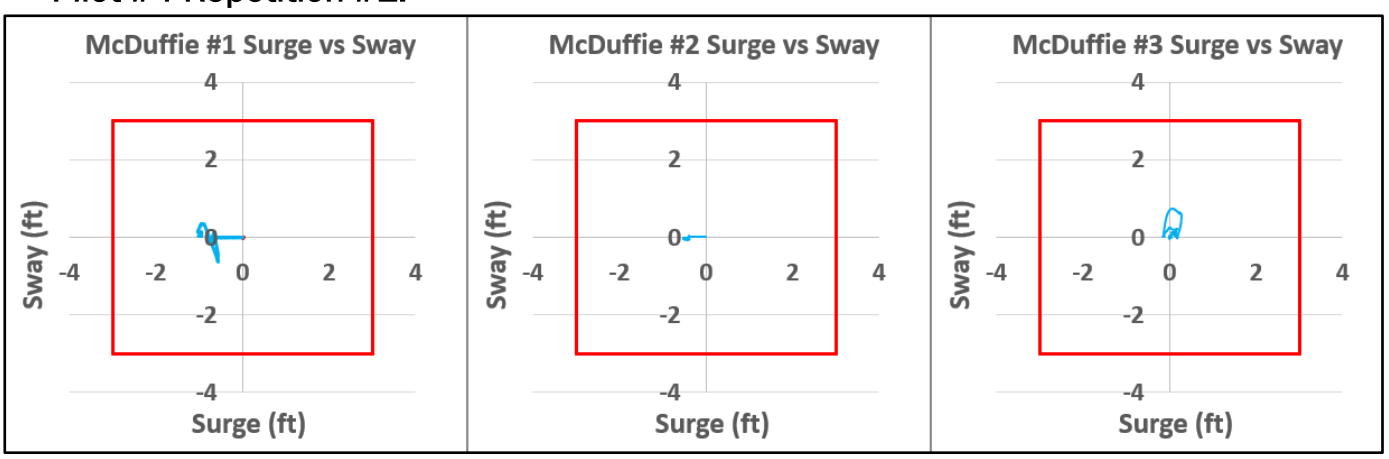
Informational Graphs Plate 23

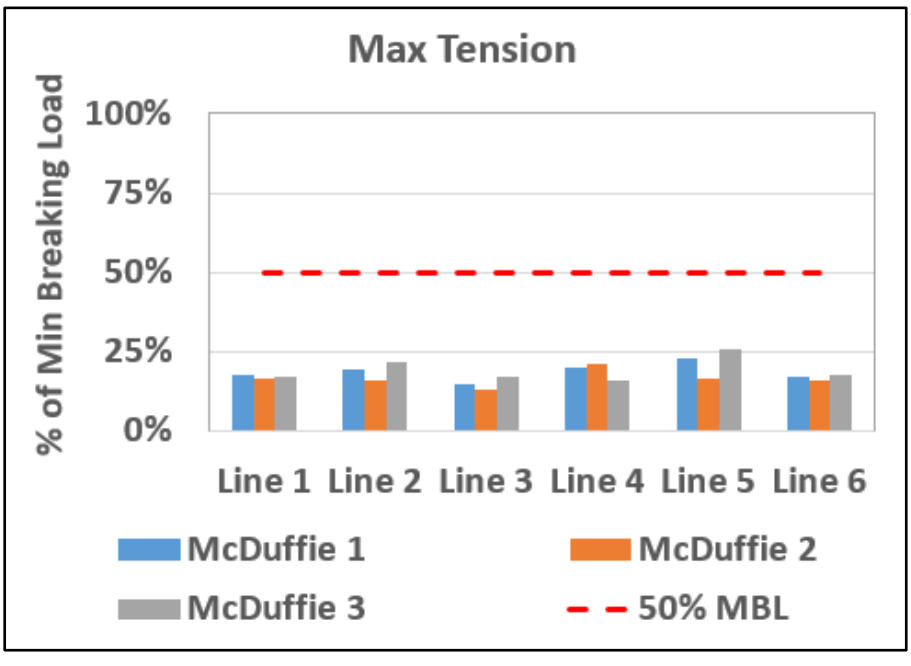
Pilot #3 Repetition #1:





Pilot #4 Repetition #1:





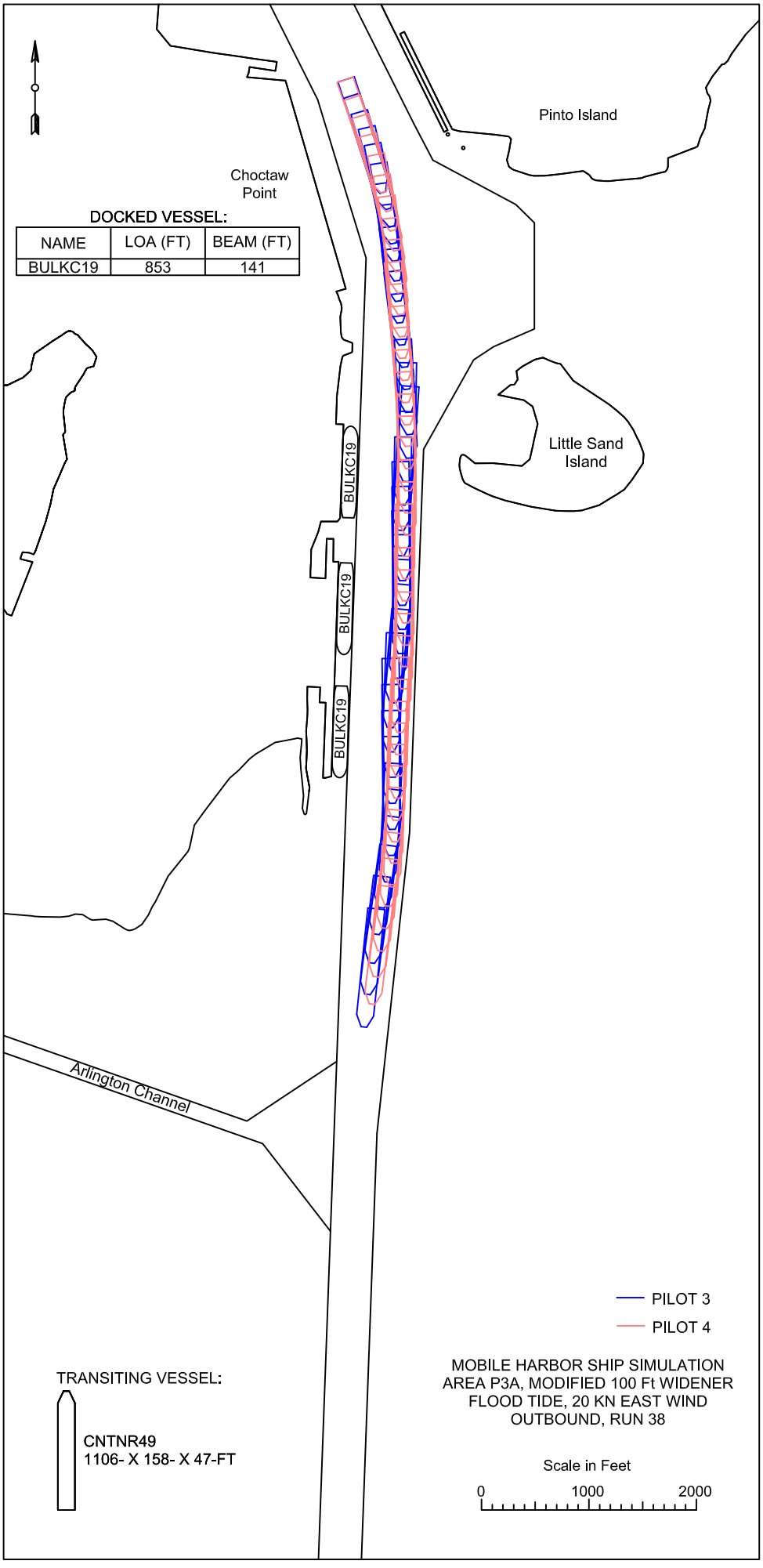

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
FLOOD TIDE, 20 KN EAST WIND
OUTBOUND, RUN 38
Scale in Feet
0
1000
2000

Plate 23B

Informational Sheet Plate 23B

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
38	P3A	Outbound	Flood	20 knots E	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	I like (and use) all the extra room to stay away from the ships at McDuffie.		1	1
4	Was able to control heading and speed with minimal to moderate tug and engine/rudder usage.		2	1

McDuffie Information:

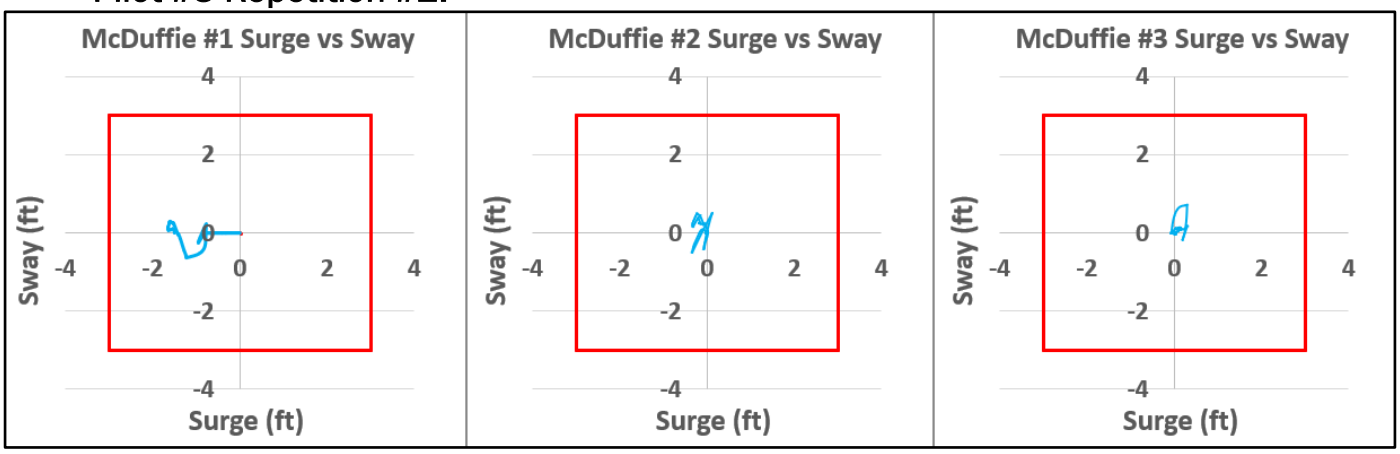
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	317	5	-1.7	-0.6	356	4.8	-0.3	-0.5	352	5	0.3	0.7
4	382	4.2	-1.2	-0.6	404	4.2	-0.2	0.4	381	4.3	0.2	0.4

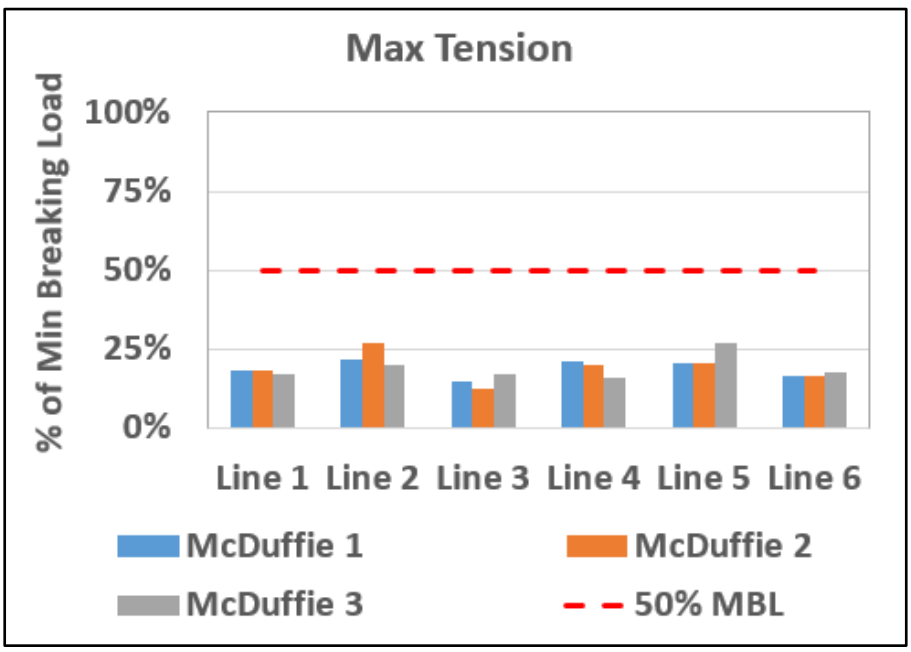
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
4	NO	NO	N/A

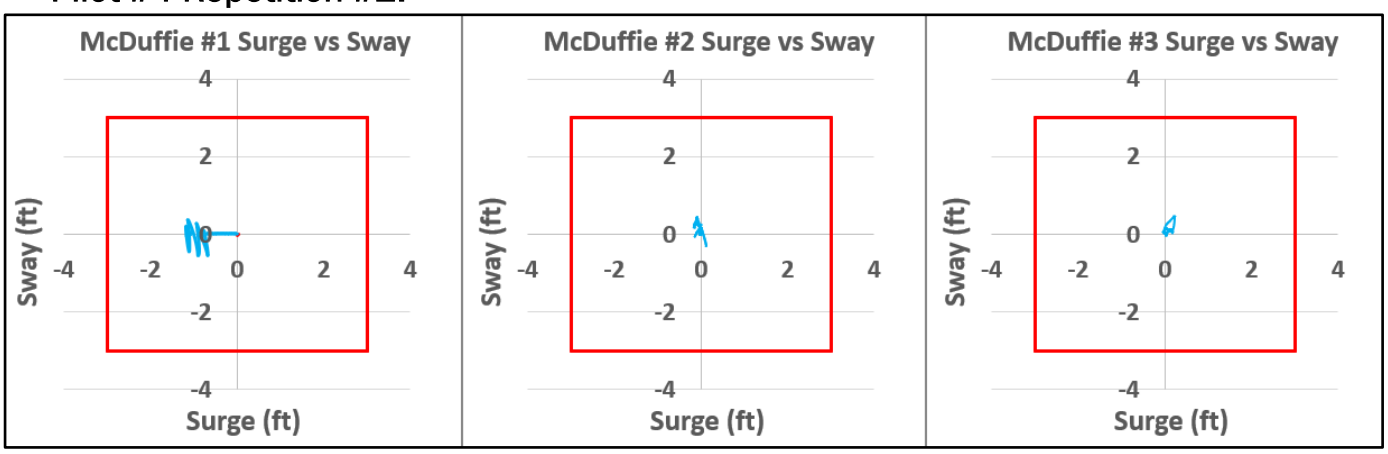
Informational Graphs Plate 23B

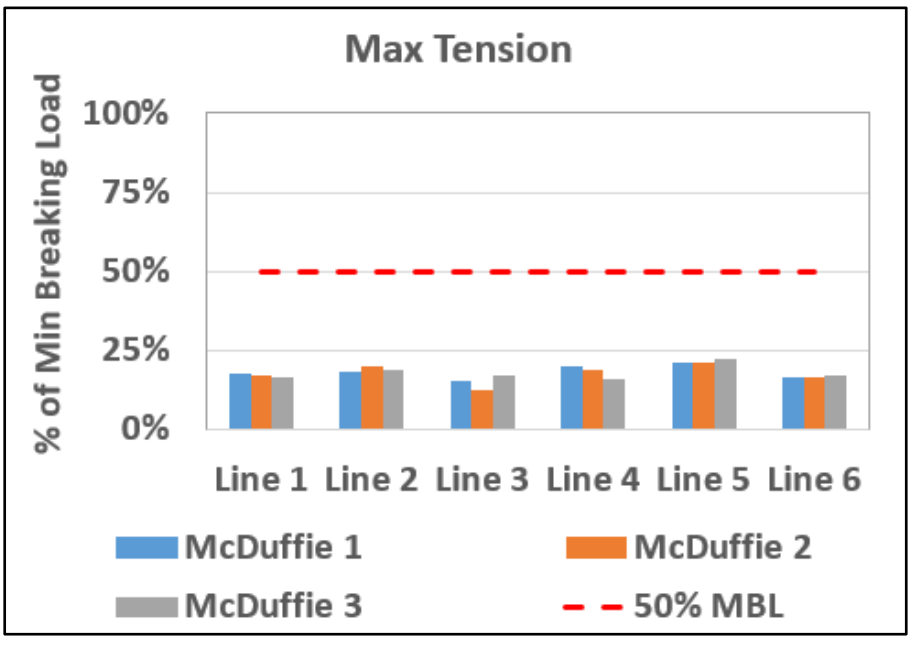
Pilot #3 Repetition #2:





Pilot #4 Repetition #2:





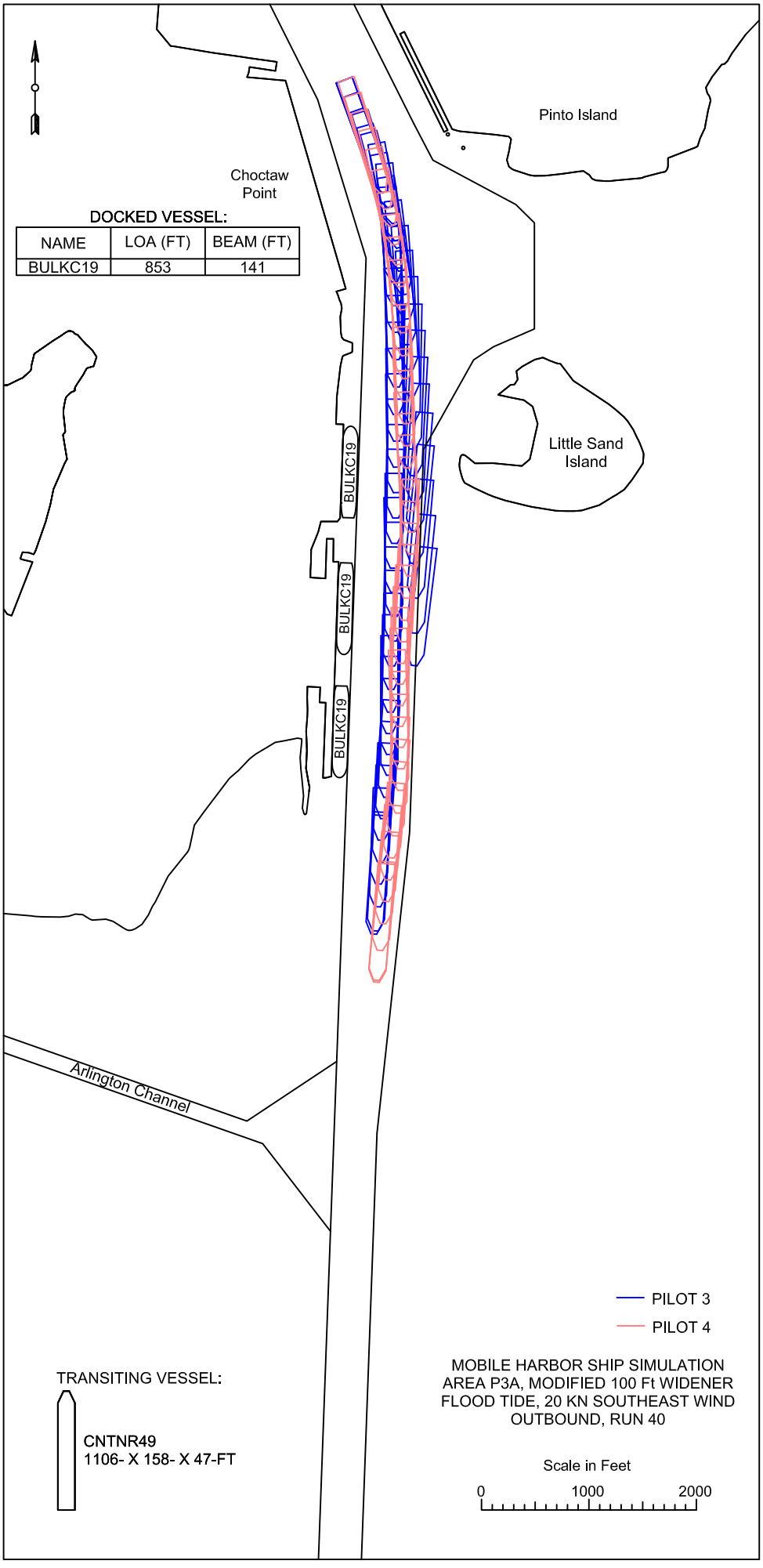

Pinto Island
Choctaw Point
DOCKED VESSEL:
NAME | LOA (FT) | BEAM (FT)
BULKC19 | 853 | 141
Little Sand Island
BULKC19
BULKC19
BULKC19
Arlington Channel
PILOT 3
PILOT 4
TRANSITING VESSEL:
CNTNR49
1106- X 158- X 47-FT
MOBILE HARBOR SHIP SIMULATION
AREA P3A, MODIFIED 100 Ft WIDENER
FLOOD TIDE, 20 KN SOUTHEAST WIND
OUTBOUND, RUN 40
Scale in Feet
0
1000
2000

Plate 24

Informational Sheet Plate 24

Conditions tested:

Run #	Alternative	Heading	Current	Wind	Vessel File
40	P3A	Outbound	Flood	20 knots SE	Vessel Manufacturer Modified

Individual simulation information:

Pilot #	Pilot Comments	Notes	Pilot Scores	
			Run Difficulty	Run Safety
3	I got too far east and could not come away from east bank.	Exceeded channel due to approach. Last run of the day for this pilot.	3	4
3	Run went as it should. Seemed to handled as a real outbound of this class/size.		1	1
4	Ran this exercise as close to 4 knots as possible and to eastern edge of channel. Was able to control speed with minimal to moderate tug usage and heading control with dead slow to slow bells.		2	1

McDuffie Information:

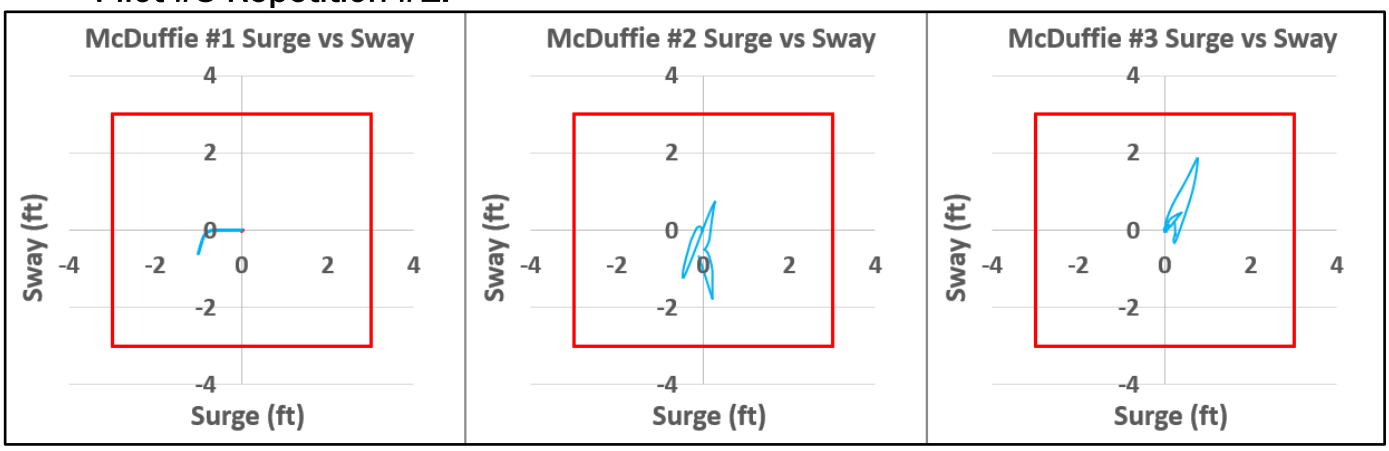
	McDuffie #1: BULKC19				McDuffie #2: BULKC19				McDuffie #3: BULKC19			
Pilot #	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)	Vessel Distance (ft)	SOW (kn)	Max Surge (ft)	Max Sway (ft)
3	-	-	-1.0	-0.6	-	-	-0.5	-1.8	503	3.9	0.8	1.9
3	301	4.2	-1.4	-1.2	287	4.5	3.4	-3.1	264	4.8	-0.4	0.9
4	405	4.2	-1.1	-0.5	404	4	0.1	0.4	394	4	0.2	0.4

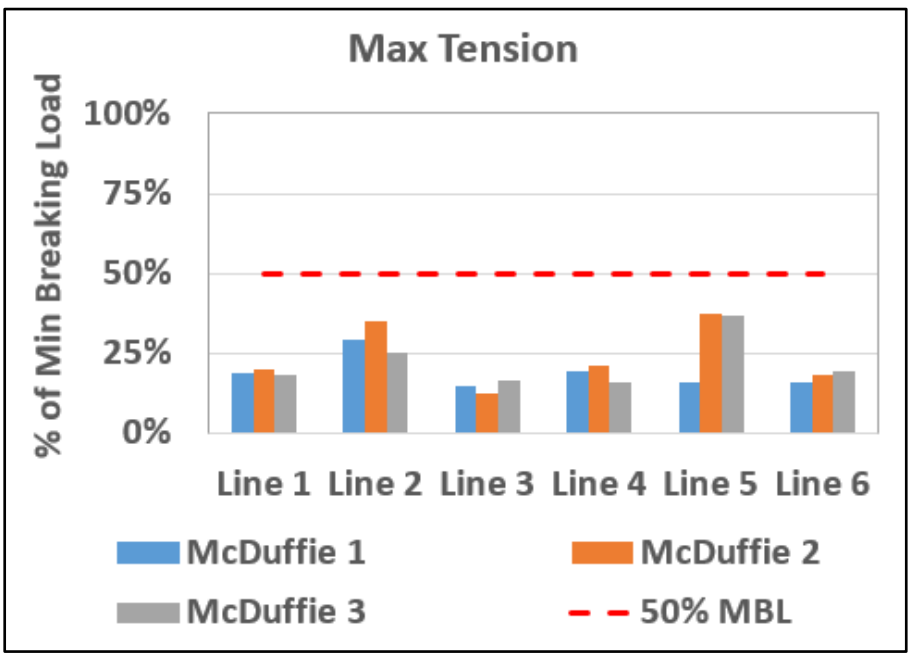
Summary:

Pilot #	Tension Exceeded?	Max Sway/Surge Exceeded?	Failure Location
3	NO	NO	N/A
3	NO	YES	McDuffie #2
4	NO	NO	N/A

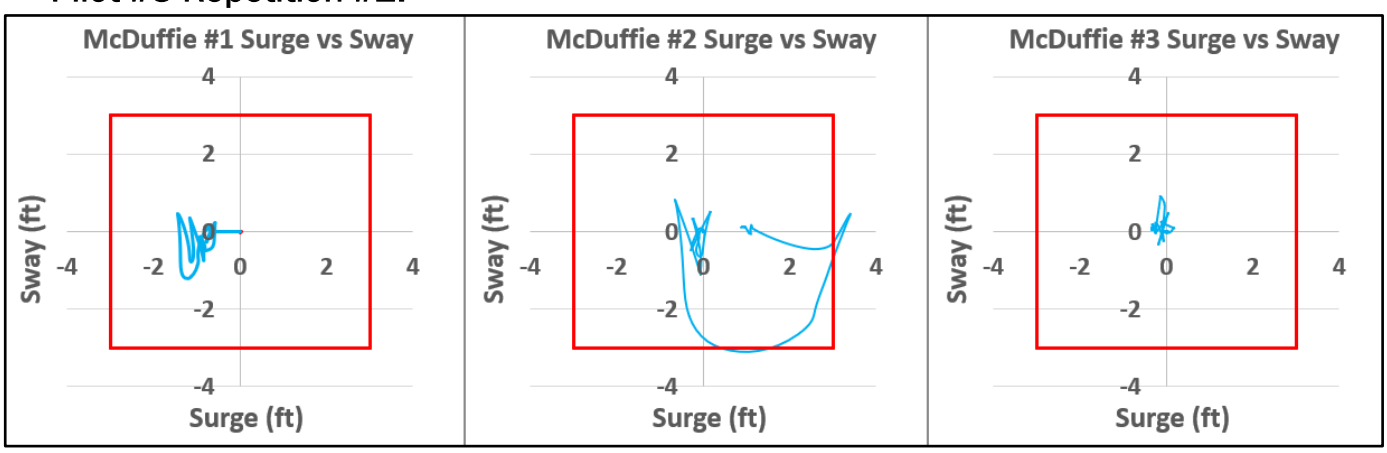
Informational Graphs Plate 24

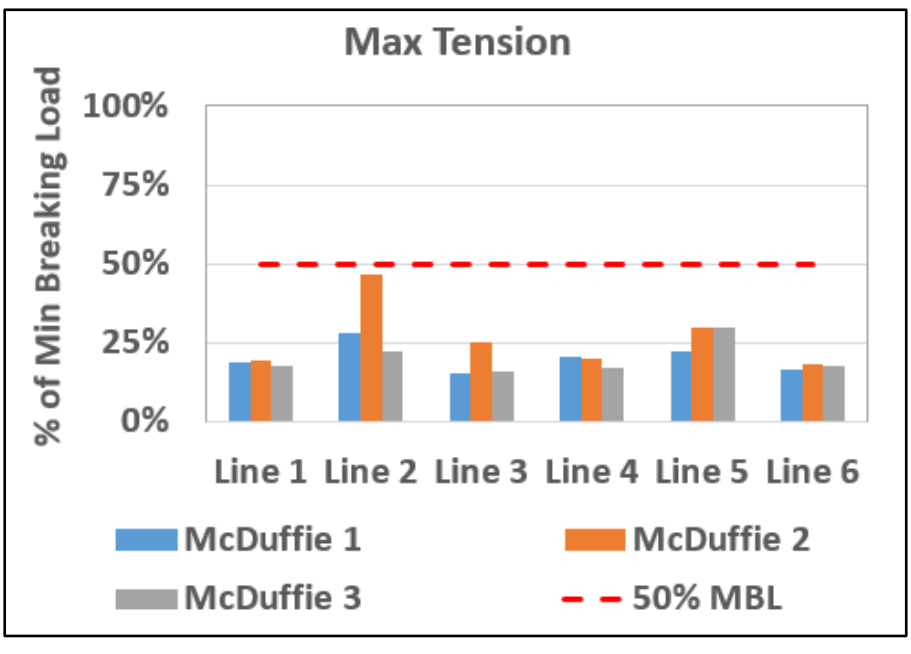
Pilot #3 Repetition #1:





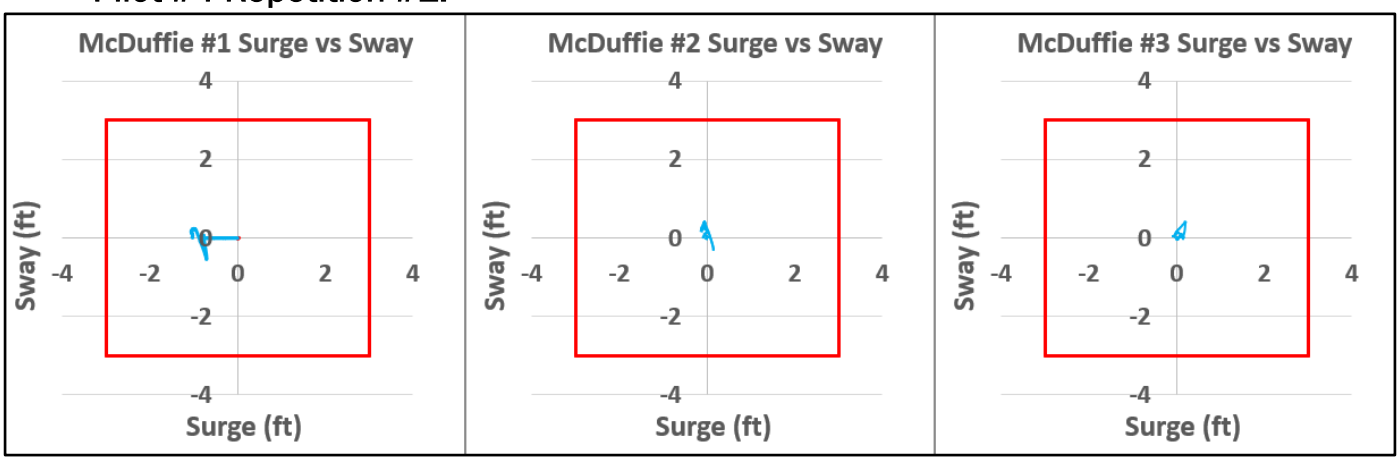
Pilot #3 Repetition #2:

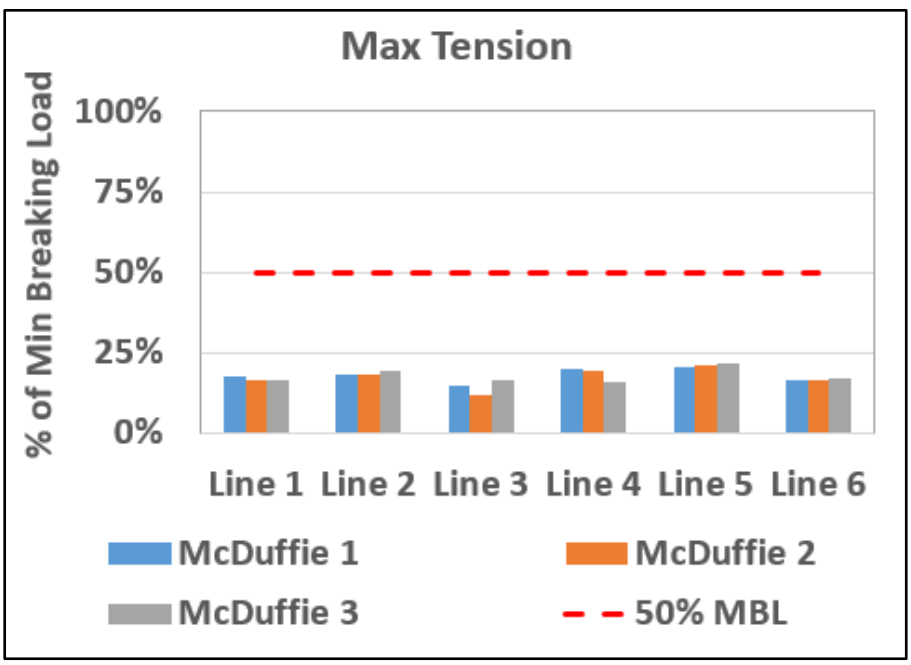




Informational Graphs Plate 24

Pilot #4 Repetition #1:





Appendix B: Final Pilot Questionnaire

Please comment on your experience of using the ERDC Ship-Tow Simulator this week for testing.			
Pilot 1 (Capt. Curtis Wilson)	**Pilot 2 (Capt. David Berault)**	**Pilot 3 (Capt. Pete Burns)**	**Pilot 4 (Capt. David Bender)**
Once we completed the validation runs, the exercises were efficient, realistic and useful.	Very helpful once we completed the validation runs. ERDC simulator personnel were very understanding of our concerns and made adjustments for a more real life experience.	The simulator was very well set up.	The simulator appeared to be fairly accurate and the controls were all within easy enough reach.

Do you feel the environmental conditions and visuals provided a reasonable representation of the Mobile Harbor under which pilots would navigate the channel?			
Pilot 1 (Capt. Curtis Wilson)	**Pilot 2 (Capt. David Berault)**	**Pilot 3 (Capt. Pete Burns)**	**Pilot 4 (Capt. David Bender)**
Yes, the wind and current environmentals were realistic.	Yes, after adjustments were made, it was close to a reasonable representation.	Very real. The effect of wind & current was very life like.	Yes.

Please comment on the behavior of the design vessel tested (*Maersk Guayaquil*- Containership: 1105.6- x 158.5- x 47-ft). Do you feel the design vessel was an adequate representation of a real life vessel?			
Pilot 1 (Capt. Curtis Wilson)	**Pilot 2 (Capt. David Berault)**	**Pilot 3 (Capt. Pete Burns)**	**Pilot 4 (Capt. David Bender)**
Yes, the vessel handled in an expected, realistic manner	Yes. Guayaquil was a normal behaving containership given the environmentals.	Yes, it was as real as it gets.	Seemed to be fairly accurate. With 47 foot draft, she was a little sluggish but responded pretty well to the rudder and ships engine.

Week 1 only question: Did you consider the McDuffie Coal Terminal Widener (P3 +100 ft) adequate for passing docked vessels at the coal terminal for a large containership (such as the design vessel tested *Maersk Guayaquil*-Containership: 1105.6- x 158.5- x 47-ft)? Why or why not?	
Pilot 1 **(Capt. Curtis Wilson)**	**Pilot 2** **(Capt. David Berault)**
Yes. The present width of the channel requires borderline hazardous conditions due to close proximity of ships this size passing McDuffie	Yes! It was adequate and gave sufficient space off the terminal. Only request is a softened taper of the entrance to the widener.

Week 2 only question: Did you consider the McDuffie Coal Terminal Widener (P2A +50 ft) adequate for passing docked vessels at the coal terminal for a large containership (such as the design vessel tested *Maersk Guayaquil*-Containership: 1105.6- x 158.5- x 47-ft)? Why or why not?	
Pilot 3 **(Capt. Pete Burns)**	**Pilot 4** **(Capt. David Bender)**
Not adequate. Too hard to enter northbound and not much more room off McDuffie.	50 ft would be helpful to improve safety and with interference of ships at McDuffie, but the 75 and/or 100 ft would be much better. The 100 foot would give you almost a ship width more to stay away from docked vessels. Vessels this size simulated need to be navigated at less than 4 knots in order not to severely interfere with the vessels moored at McDuffie.

Week 2 only question: Did you consider the McDuffie Coal Terminal Widener (P75 +75 ft) adequate for passing docked vessels at the coal terminal for a large containership (such as the design vessel tested *Maersk Guayaquil*- Containership: 1105.6- x 158.5- x 47-ft)? Why or why not?		
	Pilot 3 **(Capt. Pete Burns)**	**Pilot 4** **(Capt. David Bender)**
	Still not adequate. When you run a few ships in the 100 ft widener, you realize just how the 100ft makes it safer by far.	Refer to previous question

Week 2 only question: Did you consider the McDuffie Coal Terminal Widener (P3A +100 ft) adequate for passing docked vessels at the coal terminal for a large containership (such as the design vessel tested *Maersk Guayaquil*- Containership: 1105.6- x 158.5- x 47-ft)? Why or why not?		
	Pilot 3 **(Capt. Pete Burns)**	**Pilot 4** **(Capt. David Bender)**
	Yes! The 100ft is easy to get in and out. I think the ships at McDuffie are not going to have any issues with us passing.	Highly encourage strong consideration of 100 ft widener and to at least the south end of Arlington channel entrance.

Week 1 only question: Based upon the simulator runs, what possible limits or restrictions MIGHT be considered by the Mobile Bar Pilots for a large containership (such as the design vessel tested *Maersk Guayaquil*- Containership: 1105.6- x 158.5- x 47-ft) passing by vessels at the coal terminal with the widener tested (P3 +100 ft)?	
Pilot 1 **(Capt. Curtis Wilson)**	**Pilot 2** **(Capt. David Berault)**
Additional tug boats might be required to still help manage speed while passing.	Additional tugs may still be required to maintain safe speed.

Week 2 only question: Based upon the simulator runs, what possible limits or restrictions MIGHT be considered by the Mobile Bar Pilots for a large containership (such as the design vessel tested *Maersk Guayaquil*- Containership: 1105.6- x 158.5- x 47-ft) passing by vessels at the coal terminal with any of the wideners tested?	
Pilot 3 **(Capt. Pete Burns)**	**Pilot 4** **(Capt. David Bender)**
Maybe some sort of wind restrictions. Keep speed limit to 5 knots. Make sure adequate amount & horsepower tugs are used	Possibly a wind restriction of 25+ knots might be in order considering how close you are passing other vessels and possible set.

Week 1 only question: Did the widening across from the McDuffie Coal Terminal (P3 +100 ft) improve safety when transiting by the docked vessels?	
Pilot 1 **(Capt. Curtis Wilson)**	**Pilot 2** **(Capt. David Berault)**
Yes, more deep water allows for less suction on the docked vessels.	Yes. More room for maneuvering equaled more room for error, but more importantly, more room equals less interaction between ships. Thus, preventing damage to ships at McDuffie or loading equipment.

Week 2 only question: Did the widenings across from the McDuffie Coal Terminal improve safety when transiting by the docked vessels? a. P2A +50 ft b. P75 +75 ft c. P3A +100 ft	
Pilot 3 **(Capt. Pete Burns)**	**Pilot 4** **(Capt. David Bender)**
a. Yes b. Yes c. Very much so	a. Somewhat b. Better c. Most

Were simulations representative of real-life piloting operations?			
Pilot 1 (Capt. Curtis Wilson)	**Pilot 2 (Capt. David Berault)**	**Pilot 3 (Capt. Pete Burns)**	**Pilot 4 (Capt. David Bender)**
Yes.	Yes.	Yes.	Felt the simulator was very realistic.

Do you think there were any additional testing runs that should have been completed that were not tested this week?			
Pilot 1 (Capt. Curtis Wilson)	**Pilot 2 (Capt. David Berault)**	**Pilot 3 (Capt. Pete Burns)**	**Pilot 4 (Capt. David Bender)**
Any additional will be properly tested by the next group. Time constraint is the only reason.	I felt the runs we conducted were sufficient and covered the bases well.	I think we covered all of the bases here	Perhaps some runs with winds with some westerly influence.

Any additional comments?			
Pilot 1 (Capt. Curtis Wilson)	**Pilot 2 (Capt. David Berault)**	**Pilot 3 (Capt. Pete Burns)**	**Pilot 4 (Capt. David Bender)**
As always, the team working with us in the simulator are professional, helpful, and effective. Thanks for helping us test for this crucial need in our port.	Thank you Morgan, Kiara, and team for a job well done!	Your staff here does a great job and are a joy to work with. Thanks.	The widener project will be helpful for this class of vessel and smaller passing McDuffie. For any vessels much larger than this, I truly believe that with the set and safety concerns of speed at McDuffie, that the whole stretch from Buoys 73+74 up to the turning basin will need to be widened and centerline moved east. Thanks.

Appendix C: Pilot Cards

The following six pages present pilot cards.

PILOT CARD

CNTNR49V1
Version 1

Ship's name Maersk Guayaquil

Call Sign VROS8 **Deadweight** 119359 tonnes **Year built** 2015

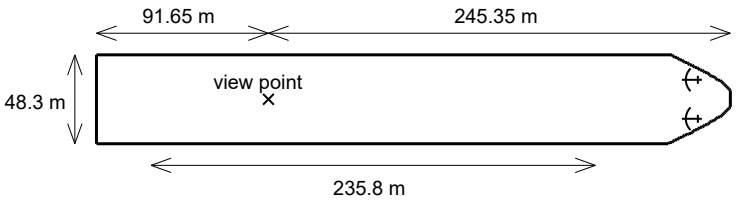
Draught aft 14.33 m / 47 ft 0 in **Forward** 14.33 m / 47 ft 0 in **Displacement** 155190 tonnes

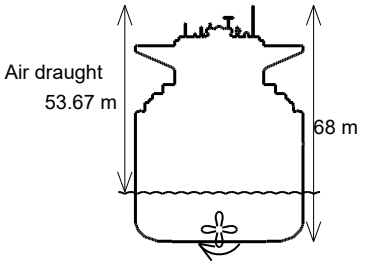
SHIP'S PARTICULARS

Length overall 337 m **Anchor chain:** **Port** 13.0 shackles **Starboard** 13.0 shackles

Breadth 48.3 m

Bulbous bow Yes **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 58118 kW (79019 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	PLoaded
Full sea speed	**1**	81.0	N/A	N/A	23.0
Full Ahead	**0.8**	54.0	N/A	N/A	15.6
Half Ahead	**0.5**	40.0	N/A	N/A	11.5
Slow Ahead	**0.25**	28.0	N/A	N/A	8.0
Dead Slow Ahead	**0.125**	21.0	N/A	N/A	6.0
Dead Slow Astern	**-0.125**	-21.0	N/A		
Slow Astern	**-0.25**	-28.0	N/A		
Half Astern	**-0.5**	-40.0	N/A		
Full Astern	**-1**	-54.0	N/A		

STEERING PARTICULARS

Type of rudder Normal **Maximum angle** 35 °

Hard-over to hard-over 11.3 s

Rudder angle for neutral effect 0 °

Thruster: **Bow** 2410 kW (3277 hp) **Stern** N/A kW (N/A hp)

CHECKED IF ABOARD AND READY

Anchors			**Indicators:**		
Whistle			**Rudder**		
Radar		3 cm	**Rpm/pitch**		
ARPA			**Rate of turn**		
Speed log		**Doppler:** Yes / No	**Compass system**		
Water speed			**Constant gyro error ±**		°
Ground speed			**VHF**		
Dual-axis			**Elec. pos. fix. system**		
Engine telegraphs			**Type**		
Steering gear					
Number of power units operating					

OTHER INFORMATION:

PILOT CARD

BULKC19V2
Version 2

Ship's name Regina Oldendorff

Call Sign CQIB2 **Deadweight** 118863 tonnes **Year built** 2011

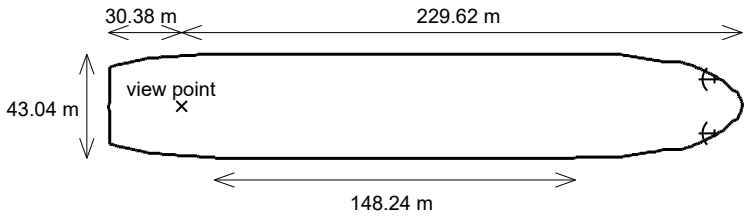
Draught aft 14.33 m / 47 ft 0 in **Forward** 14.33 m / 47 ft 0 in **Displacement** 131735 tonnes

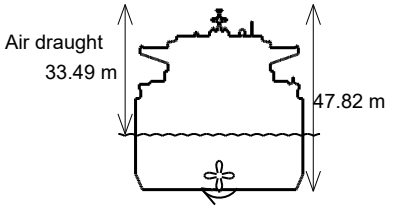
SHIP'S PARTICULARS

Length overall 260 m **Anchor chain:** **Port** 11.5 shackles **Starboard** 11.5 shackles

Breadth 43.04 m

Bulbous bow Yes **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 13558 kW (18433 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	**1**	99.5	N/A	14.5	N/A
Full Ahead	**0.8**	86.0	N/A	12.6	N/A
Half Ahead	**0.5**	66.0	N/A	9.6	N/A
Slow Ahead	**0.25**	44.0	N/A	6.3	N/A
Dead Slow Ahead	**0.125**	30.0	N/A	4.2	N/A
Dead Slow Astern	**-0.125**	-30.0	N/A		
Slow Astern	**-0.25**	-44.0	N/A		
Half Astern	**-0.5**	-66.0	N/A		
Full Astern	**-1**	-86.0	N/A		

STEERING PARTICULARS

Type of rudder Normal **Maximum angle** 35 °

Hard-over to hard-over 13.5 s

Rudder angle for neutral effect 0 °

Thruster: **Bow** N/A kW (N/A hp) **Stern** N/A kW (N/A hp)

CHECKED IF ABOARD AND READY

Anchors			**Indicators:**		
Whistle			**Rudder**		
Radar		3 cm	**Rpm/pitch**		
ARPA			**Rate of turn**		
Speed log		**Doppler:** Yes / No	**Compass system**		
Water speed			**Constant gyro error ±**		°
Ground speed			**VHF**		
Dual-axis			**Elec. pos. fix. system**		
Engine telegraphs			**Type**		
Steering gear					
Number of power units operating					

OTHER INFORMATION:

PILOT CARD

VLCC13P1
Version 1

Ship's name Orion Voyager

Call Sign C6MC5 **Deadweight** 156500 tonnes **Year built** 1994

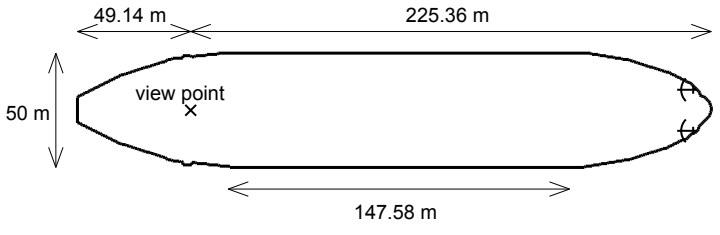
Draught aft 14.63 m / 47 ft 12 in **Forward** 14.63 m / 47 ft 12 in **Displacement** 151663 tonnes

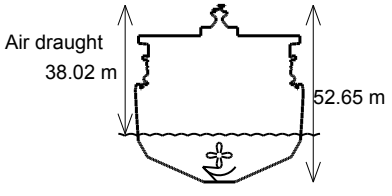
SHIP'S PARTICULARS

Length overall 274.5 m **Anchor chain:** **Port** 13.0 shackles **Starboard** 14.0 shackles

Breadth 50 m

Bulbous bow Yes **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 14872 kW (20220 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	PLoaded
Full sea speed	**1**	92.0	N/A	N/A	15.7
Full Ahead	**0.8**	77.0	N/A	N/A	13.2
Half Ahead	**0.5**	54.0	N/A	N/A	9.2
Slow Ahead	**0.25**	35.0	N/A	N/A	5.9
Dead Slow Ahead	**0.125**	25.0	N/A	N/A	4.1
Dead Slow Astern	**-0.125**	-25.0	N/A		
Slow Astern	**-0.25**	-31.7	N/A		
Half Astern	**-0.5**	-45.1	N/A		
Full Astern	**-1**	-72.0	N/A		

STEERING PARTICULARS

Type of rudder Normal **Maximum angle** 45 °

Hard-over to hard-over 35.4 s

Rudder angle for neutral effect 0 °

Thruster: **Bow** N/A kW (N/A hp) **Stern** N/A kW (N/A hp)

CHECKED IF ABOARD AND READY

Anchors ☐

Whistle ☐

Radar ☐ 3 cm ☐ 10 cm

ARPA ☐

Speed log ☐ **Doppler:** Yes / No

Water speed ☐

Ground speed ☐

Dual-axis ☐

Engine telegraphs ☐

Steering gear ☐

Number of power units operating ☐

Indicators: ☐

Rudder ☐

Rpm/pitch ☐

Rate of turn ☐

Compass system ☐

Constant gyro error ± ____ °

VHF ☐

Elec. pos. fix. system ☐

Type ____

OTHER INFORMATION:

Abbreviations

ADCIRC	Advanced Circulation
CESAM	US Army Corps of Engineers, Mobile District
E	East
ERDC	US Army Engineer Research and Development Center
FLSS	Feasibility Level Screening Simulation
HQ	High flow
LQ	Low flow
MBL	Minimum breaking load
MLLW	Mean lower low water
N	North
P2	Project Alternative 2
P3	Project Alternative 3
P4	Project Alternative 4
P75	Project Alternative 75
SAM	Mobile District
SE	Southeast
STS	Ship/Tow Simulator
USACE	US Army Corps of Engineers

REPORT DOCUMENTATION PAGE

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED	
		START DATE	END DATE
September 2023	Final report	FY22	FY22

4. TITLE AND SUBTITLE

Surge Analysis in Mobile Harbor, Alabama: Ship-Simulation Report

5a. CONTRACT NUMBER	5b. GRANT NUMBER	5c. PROGRAM ELEMENT
5d. PROJECT NUMBER	**5e. TASK NUMBER**	**5f. WORK UNIT NUMBER**

6. AUTHOR(S)

Morgan M. Johnston, Kiara I. Pazan, Yan Ding, Mary Claire Allison, and Sung-Chan Kim

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

US Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/CHL TR-23-11

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
US Army Corps of Engineers, Mobile District PO Box 2288 Mobile, AL 36628-0001	CESAM	

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Statement A. Approved for public release: distribution is unlimited.

13. SUPPLEMENTARY NOTES

Funding Account Code U4379870; AMSCO Code 076126

14. ABSTRACT

A navigation channel improvement study for Mobile Harbor was conducted by the US Army Corps of Engineers, Mobile District (CESAM), and the Alabama State Port Authority. The US Army Engineer Research and Development Center (ERDC) assisted CESAM in assessing channel modifications using ERDC's Ship/Tow Simulator through a Feasibility Level Screening Simulation study in 2017 and through a more comprehensive ship-simulation study in 2020. During the 2020 study, a safety concern was identified related to vessel interactions between a transiting vessel passing docked vessels at the McDuffie Coal Terminal located along the main federal channel. In the previous ship-simulation studies, the docked vessels were represented as targets, which means the ships are visually represented but no hydrodynamic interaction is captured. To fully assess this interaction, a surge-analysis study was completed in 2022 that used hydrodynamic models to represent docked vessels with representative mooring conditions. This study assessed several proposed navigation channel expansions across from the McDuffie Coal Terminal over the course of six testing days with four pilots. Assessment of the proposed modifications was accomplished through analysis of ship simulations completed by experienced local pilots, track plots, run sheets, and final pilot questionnaires.

15. SUBJECT TERMS

Channels (Hydraulic engineering); Harbors--Mobile (Ala.); Hydronynamics; Inland navigation--Computer simulation; Mobile Bay (Ala.); Ships--Computer simulation

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES
a. REPORT	b. ABSTRACT	C. THIS PAGE		
Unclassified	Unclassified	Unclassified	SAR	184

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