Coastal Texas Protection and Restoration Feasibility Study

Final Feasibility Report

Appendix D – Annex 14:

Ship Simulations

August 2021

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DEPARTMENT OF THE ARMY
ENGINEER RESEARCH AND DEVELOPMENT CENTER, CORPS OF ENGINEERS
COASTAL AND HYDRAULICS LABORATORY
WATERWAYS EXPERIMENT STATION, 3909 HALLS FERRY ROAD
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REPLY TO
ATTENTION OF

CEERD-HNN-D

MEMORANDUM FOR Commander, U.S. Army Corps of Engineers, Galveston District (CESWGEC-HB /Dr. Himangshu Das), PO Box 1229, Galveston, TX 077550

SUBJECT: Coastal Texas Protection & Restoration Feasibility Study Report

1. Enclosed is a copy of the Coastal Texas Protection & Restoration Feasibility Study Report.

2. A Feasibility Level Screening Simulation Program (FLSSP) study for the proposed Coastal Storm Surge Reduction Measures (CSRM) alignment and gate structure across Bolivar Roads was conducted the week of 20-23 February 2019, at the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory's Ship/Tow Simulator (STS). The purpose of the study was to obtain expert elicitation from the Galveston-Texas City Pilots resulting from the participation in ship simulation exercises at the ERDC. The results of the FLSSP are enclosed.

3. If you have any questions, please contact Mr. Keith Martin at (601) 634-3019 or Mr. Timothy W. Shelton, Chief, Navigation Branch at (601) 634-2304.

Encls

TY V. WAMSLEY, PhD, SES
Director

Coastal Texas Protection & Restoration Feasibility Study Report

1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) has completed a Feasibility Level Screening Simulation Program (FLSSP) to assist the USACE Galveston District (CESWG) in analyzing the proposed Coastal Storm Surge Reduction Measures (CSRM) alignment and gate structure across Bolivar Roads which has been proposed as a Tentatively Selected Plan (TSP) for the ongoing Coastal Texas Protection & Restoration Feasibility project. The study was performed at CHL's Ship/Tow Simulator (STS) on 20-23 February 2019.

2. OVERVIEW

The TSP identified by the Coastal Texas Protection & Restoration Feasibility Study consists of a coastal barrier system aimed to protect the Galveston Bay region from storm surge. The proposed barrier system is a closure structure consisting of a 1200 foot (ft) sector gate and environmental lift gates. The proposed location is across Bolivar Roads, between Bolivar Peninsula and Galveston Island (Figure 1). Currently, there are three deep draft navigation channels that use the entrance channel at Bolivar Roads: Houston Ship Channel, Galveston Ship Channel, and Texas City Ship Channel. The effects the structure will have on ship traffic will depend on its alignment.

Two alternative alignments are studied in this FLSSP. The first alignment is located immediately east of Galveston Channel (Figure 2). This location is a concern for inbound ship traffic heading towards Galveston as it reduces the amount of time and space for ships to complete the southward turn upon exiting the proposed structure. The second alignment is shifted approximately 3,150 ft east of the first alignment (Figure 2). The immediate areas of concern include the loss of maneuvering area and potential increase in current velocity. The ship simulation study evaluates whether the proposed alignments are feasible for maneuvering in and out of the Galveston Channel.

3. PURPOSE

The FLSSP provides a means of conducting expert elicitations. The use of real-time simulation provides an iterative framework within which to examine ideas and possible solutions within the confines of a laboratory experiment. At the conclusion of each simulation, results from the simulation can be discussed, modifications made, and then the simulation rerun. The FLSSP was conducted in order to provide essential information for the study process and to stay within the time and cost constraints of USACE's SMART Planning. To reduce time and cost, lower resolution databases are used for ship simulation and data processing is minimized. Lower resolution databases require less costly development and also allow database modification to be done quickly during the simulation week. A low resolution database can be modified (widened, realigned, tapered, etc.) within a few hours. This is critical so that ideas suggested by the pilots or others can actually be tested with the same pilots. Conclusions drawn from actual data should be limited and done very carefully due to the low resolution modeling and the assumptions used during modeling. In addition, once the meetings occur, the pilots often performed “what if” tests to check bank effects and other forces. Data processing is limited to presentation of track plots and run sheets to document results. The most important analysis is the group discussion at the conclusion of the FLSSP.

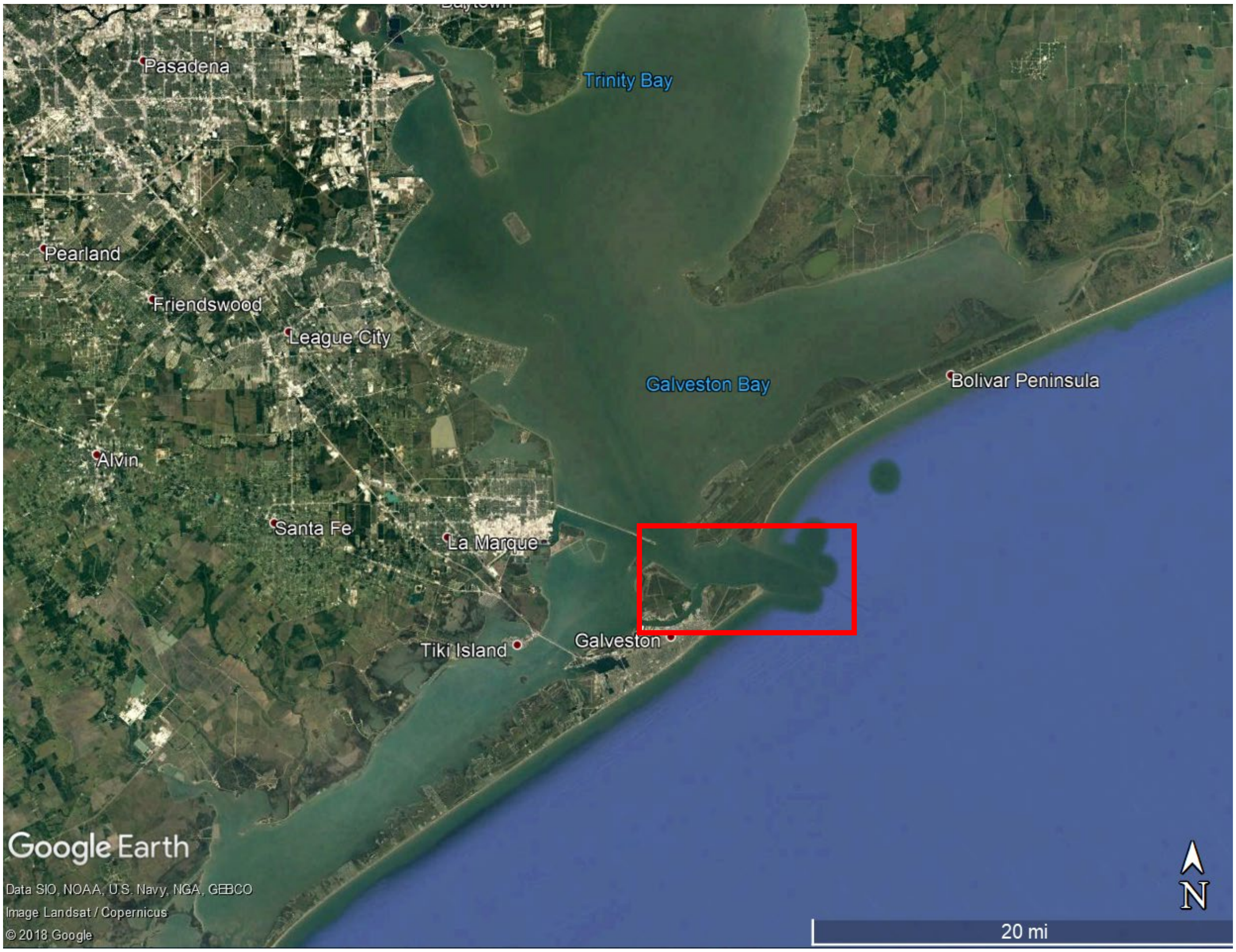
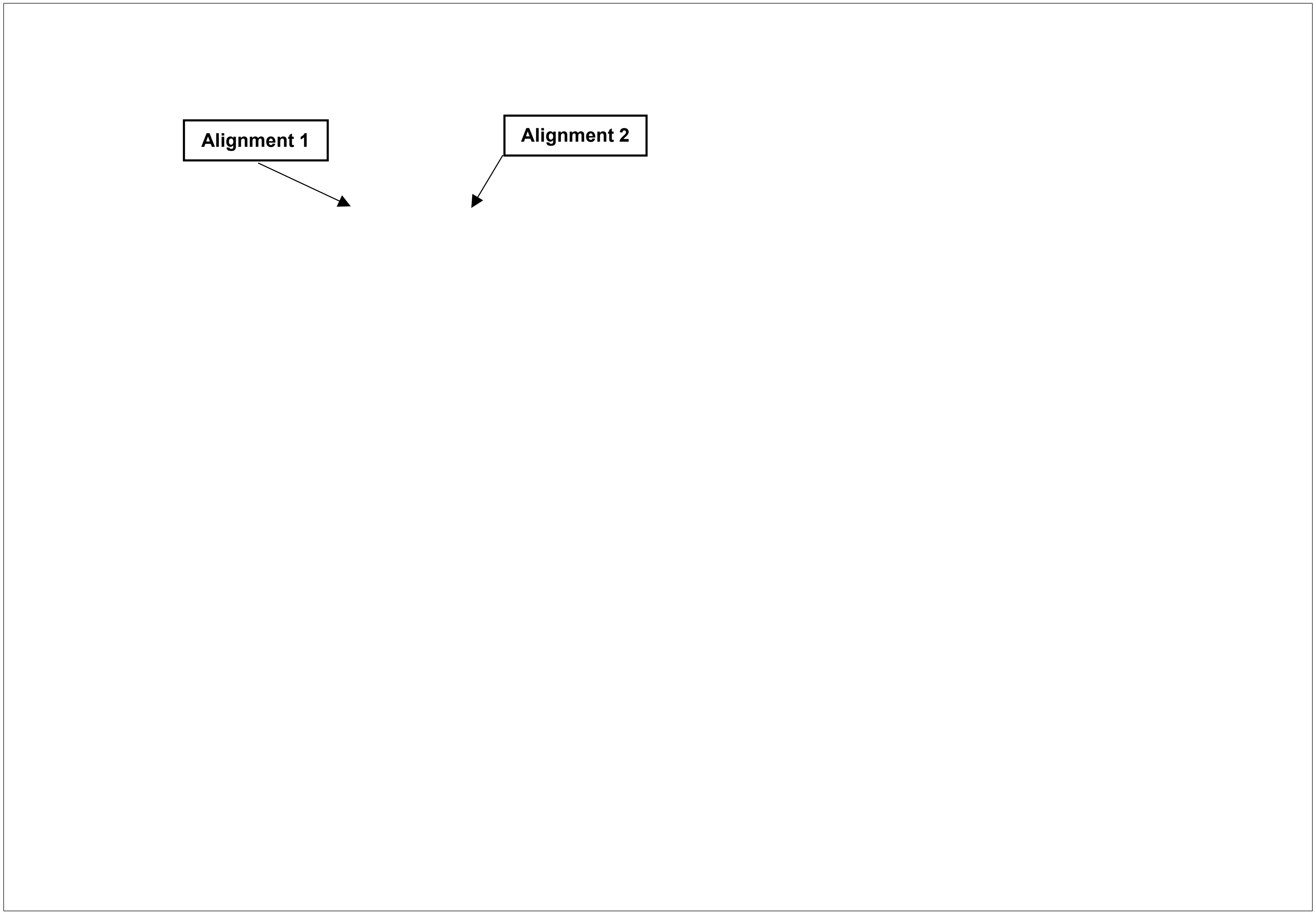


Figure 1. Location Map. Study area outlined in red box.



`Figure 2. Navigation Chart featuring proposed structure locations

4. PARTICIPANTS

The FLSSP includes representatives from ERDC, CESWG, Texas General Land Office (GLO), Galveston-Texas City Pilots, and Houston Pilots. The individuals listed participated for the duration of the simulation testing unless otherwise noted. A minimum of two pilots is generally required for feasibility level simulations. A second pilot from the Houston Pilots was scheduled to participate in testing, but due to an emergency, could not attend.

- ERDC: Keith Martin, Kiara Pazan, Mary Claire Allison, Morgan Johnston, and Mario Sanchez
- CESWG: Himangshu Das and Mike Diaz
- GLO: Carla Kartman
- Galveston-Texas City Pilots: Captain Christos Sotirelis
- Houston Port Pilots: JJ Plunkett (Observer)

5. CONSIDERATIONS

To reduce time and cost, lower resolution databases were used to reduce database development cost. Below are the parameters and assumptions used during testing

a. Currents for max ebb and max flood were obtained from an Adaptive Hydraulics (AdH) model that was run for existing condition and for the proposed alternatives. For the proposed alternatives, the gate structure was simplified to a wall and targeted openings.

b. The visual scenes consist of the background terrain and a few selected building/facility features. The proposed structure was included in visuals.

c. Wind conditions were set at run time at 25 knots from the North. This represented an adverse condition based on pilot input.

d. Simulated ships were limited to ships already in ERDC's STS inventory. The tanker, VLCC05B, and the cruise ship, *Freedom of the Seas*, were used as the design ships for the FLSSP. The dimensions of the ships are listed in Table 1. Pilot cards are included in Appendix A. The dimensions of the VLCC05B are slightly smaller than typical vessels handled in Galveston, about 60 ft shorter and 42 ft narrower. Also, VLCCs are typically called into Texas City over Galveston. Since the study is in feasibility phase, the modeled VLCC is adequate.

Table 1. Ship Models for Simulation Tests				
Model	Name	LOA (ft)	Beam (ft)	Draft (ft)
VLCC05B	-	1033.5	154.9	36.1
CRUIS09L	*Freedom of the Seas*	1111.2	126.6	27.9

6. SIMULATED SCENARIOS

Two alternative locations of the gate structure provided by CESWG were simulated: the initially proposed alignment, closest to the entrance of the Galveston, and the second alignment shifted to the east. Additional runs using currents scaled by a 25 percent increase were included to simulate a strong storm condition. The channel lines for Alignment 2 had to be adjusted in the simulator to accommodate the 1200 ft gate opening. At this alignment, the channel width is 800 ft.

Pre-programmed passing ships were included in several runs to simulate the heavy congestion in the meeting area. Vessel placement and speed was provided by the pilot. Because the routes are programmed, passing ship effects are not observed in the simulation. The ship to ship interaction can be only observed when both ships are being handled by pilots. The observations remain useful for spatial awareness. Combinations of the vessels in Table 2 were used.

Table 2. Pre-Programmed Passing Ships				
Model	Name	LOA (ft)	Beam (ft)	Draft (ft)
CNTNR21L	KMSS Ultra	935.0	131.2	41.7
CNTNR44	Zim Piraeus	964.9	105.6	43.0
VLCC15B	MT Brittania	859.6	137.8	27.2

A summary of the runs simulated are shown in the test matrix in Table 3. Existing conditions are referred to as P0, and the proposed Alignment 1 and 2 are referred to as P1 and P2, respectively.

Table 3. Test Matrix					
Alt	**Vessel**	**Tide**	**Direction**	**Wind**	**Meeting**
P0	VLCC05B	Flood	Inbound	N25K	
	CRUIS09L	Flood	Inbound	0K	
	CRUIS09L	Flood	Outbound	N25K	
P1	VLCC05B	Ebb	Inbound	N25K	
	VLCC05B	Flood	Inbound	N25K	
	VLCC05B	Flood	Inbound	N25K	CNTNR21L and VLCC15B out from Houston
	VLCC05B	Flood-25%	Inbound	N25K	CNTNR21L and VLCC15B out from Houston
	VLCC05B	Ebb	Outbound	N25K	
	VLCC05B	Flood	Outbound	N25K	CNTNR21L inbound
	VLCC05B	Ebb	Outbound-Houston	N25K	
	VLCC05B	Ebb	Outbound-Houston	N25K	CNTNR21L inbound
	CRUIS09L	Ebb	Inbound	N25K	
	CRUIS09L	Flood	Inbound	N25K	
	CRUIS09L	Flood	Inbound	N25K	CNTNR44 out from Houston
	CRUIS09L	Ebb	Outbound	N25K	
	CRUIS09L	Ebb-25%	Outbound	N25K	CNTNR21L inbound, VLCC15B outbound
	CRUIS09L	Flood	Outbound	N25K	
P2	VLCC05B	Ebb	Inbound	N25K	
	VLCC05B	Flood	Inbound	N25K	CNTNR21L and VLCC15B out from Houston
	VLCC05B	Ebb	Outbound	N25K	CNTNR21L inbound
	VLCC05B	Flood	Outbound	N25K	
	CRUIS09L	Flood	Inbound	N25K	CNTNR21L and VLCC15B out from Houston
	CRUIS09L	Ebb	Outbound	N25K	CNTNR21L inbound, VLCC15B outbound
	CRUIS09L	Ebb-25%	Outbound	N25K	
	CRUIS09L	Flood	Outbound	N25K	CNTNR21L inbound, VLCC15B outbound

7. RESULTS

The initial validation effort was devoted to pilot familiarization and model adjustment. The environmental (wind and currents), and visual databases are deemed adequate for feasibility level testing. Data recorded during these exercises provide value in observing the current turning maneuver into Galveston Channel. This varies with pilot preference, but can be used to generally compare with the vessel tracks in the alternatives.

Exercises were one-way transits, either inbound or outbound, passing through the structure. Two-way transits were also conducted using pre-programmed ships that not include ship-to-ship interaction. The initial and end vessel positions are outside the jetties, at buoys 5 and 6, and approximately 1 mile into Galveston Harbor.

A total of 25 test runs were completed (Table 3). Track plots and run sheets for the FLSSP are included in Appendix B. Figure 3 is a photograph taken from the bridge of the design ship leaving the structure.

Figure 3. View from the *Freedom of the Seas*, heading inbound towards the structure.

8. DISCUSSION

The simulation program is a screening tool used to determine the feasibility of the storm surge control structure for the Coastal Texas TSP. The final FLSSP discussion was held on Friday, 22 February 2019, while the majority of representatives were present. The following conditions are agreed upon, discussed, and recommended for the feasibility level design.

Alignment 1:
The initial proposed location, Alignment 1, for the gate structure is in close proximity to the turn into Galveston Channel, approximately 2,100 ft east of the entrance (Figure 1). After simulation runs and discussions with the pilot, it was determined that this location is not preferred.

a. The pilot was able to make the turn into Galveston successfully, but was left with very little room for not making error. After leaving the structure, the pilot needed to put in significant effort to maintain control of the ship due to the increase of current velocities. The ship needed to be in full ahead (maximum RPM) and rudder placed in the “hard over” position, leaving no additional rudder control to respond to any unexpected change in environmental conditions. Refer to comments and track plot in Appendix B-23, -24.

b. Galveston channel has a speed restriction, limiting vessels to 10 knots when entering the channel. The pilot has to balance between ensuring vessel has enough velocity to make it through the turn and not exceeding the speed restriction. Refer to comments and track plot in Appendix B-6,-7.

c. Inbound runs where the vessel is meeting outbound ships presented potentially dangerous situations where the stern is caught in front of the outbound ship when making the turn into Galveston channel.

d. The location of the southern sector gate removes the use of the Galveston channel’s bend ease. The loss of this easing in the meeting area reduces the area available for merging ships to safely pass each other. In the passing ship runs, the pilot needed to use full ahead and hard-over rudder due to the loss of the easing. Refer to comments and track plot in Appendix B-16, -17.

e. Pilots heading outbound from Houston also use this bend ease area in conditions where they need to make a wider turn. The outbound runs from Houston indicated no issues and the pilot was able to line up with the gate opening.

f. Currents at the jetties appeared to have been impacted by the structure, however pilot indicated currents behaved as expected.

g. Runs with scaled-up currents increased difficulty in making the turn and required a wider turning area, again leaving no room for error (Appendix B-28, -29).

h. Representatives from Galveston-Texas City Pilots and Houston Pilots strongly suggested against the Alignment 1 location. The merging of vessels through the meeting area is the primary concern. Refer to passing ship scenarios show in track plots B-7, -11, -17, -20, -24, -28.

Alignment 2:
The second proposed location of the gate structure is shifted approximately 0.5 mile east of Alignment 1. After simulation runs and discussions with the pilot, it was determined that this location provided increased maneuverability over Alignment 1.

a. The passing ships through the structure did not have a significant effect on transit. Vessels had sufficient space and time to align with the gate opening. The pilot described passing ship runs as “uneventful” (Appendix B-33).

b. The turn outbound can require up to 30° of rudder to complete the maneuver and is typical in existing conditions.

c. Runs using scaled up currents presented the pilot with a stronger set east of the structure through the entrance of the jetties. An increase of rudder was required in this area (Appendix B-43).

d. Pilot felt more comfortable with this alignment because of the greater distance away from the congested meeting area. The placement on the straight leg of the channel was more adequate having no immediate turns.

e. Figure 4 shows a comparison of both alignments with a cruise ship heading inbound with outbound traffic from the Houston Channel. The vessel track in the first alignment displays the immediate sharp turn required after the gate to enter Galveston Channel, while the second alignment shows a smoother vessel track (Appendix B-24, -40).

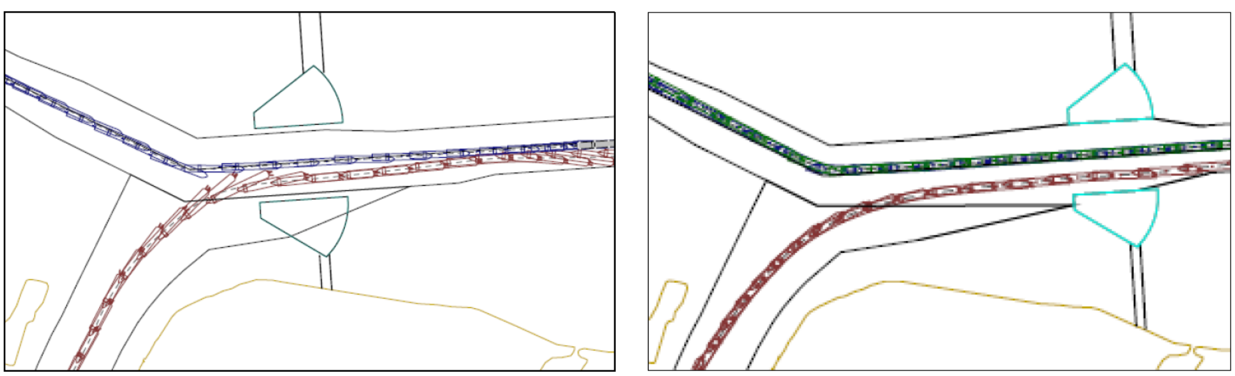


Figure 4: Comparison between Alignment 1 (left) and 2 (right) – Cruise ship turning into Galveston Channel.

No data analysis is included as part of the FLSSP as the purpose is to examine the feasibility of the gate structure alignments in the Coastal Texas Study in the CHL simulator, and to use pilot feedback as input for developing a range of feasible options. The final pilot questionnaire is provided in Appendix C. A more rigorous testing of the design is to be conducted during PED. The visual databases are to be updated to include more detail.

9. FEASIBILITY PHASE RECOMMENDATIONS

For the feasibility phase, CESWG should consider the following recommendations. This can be refined further in the PED phase ship simulations.

a. Alignment 2 as the location for surge barrier
b. Additional feasibility testing with at least two pilots. This would provide a second pilot's input and would also allow testing of passing ships with the full hydrodynamic interactions.

For future PED phase ship simulations, the following is recommended:

a. Refined hydrodynamic modeling with the actual structure outline. An additional alternative using closed environmental gates to simulate flow only going through the main gate opening.