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Sabine Neches Navigation Improvement Project Integrated Section 203 Feasibility Report and Environmental Assessment

Appendix C

Traffic Simulation Model Report

February 2026

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Traffic Simulation Model Report

1 Description of Input Data

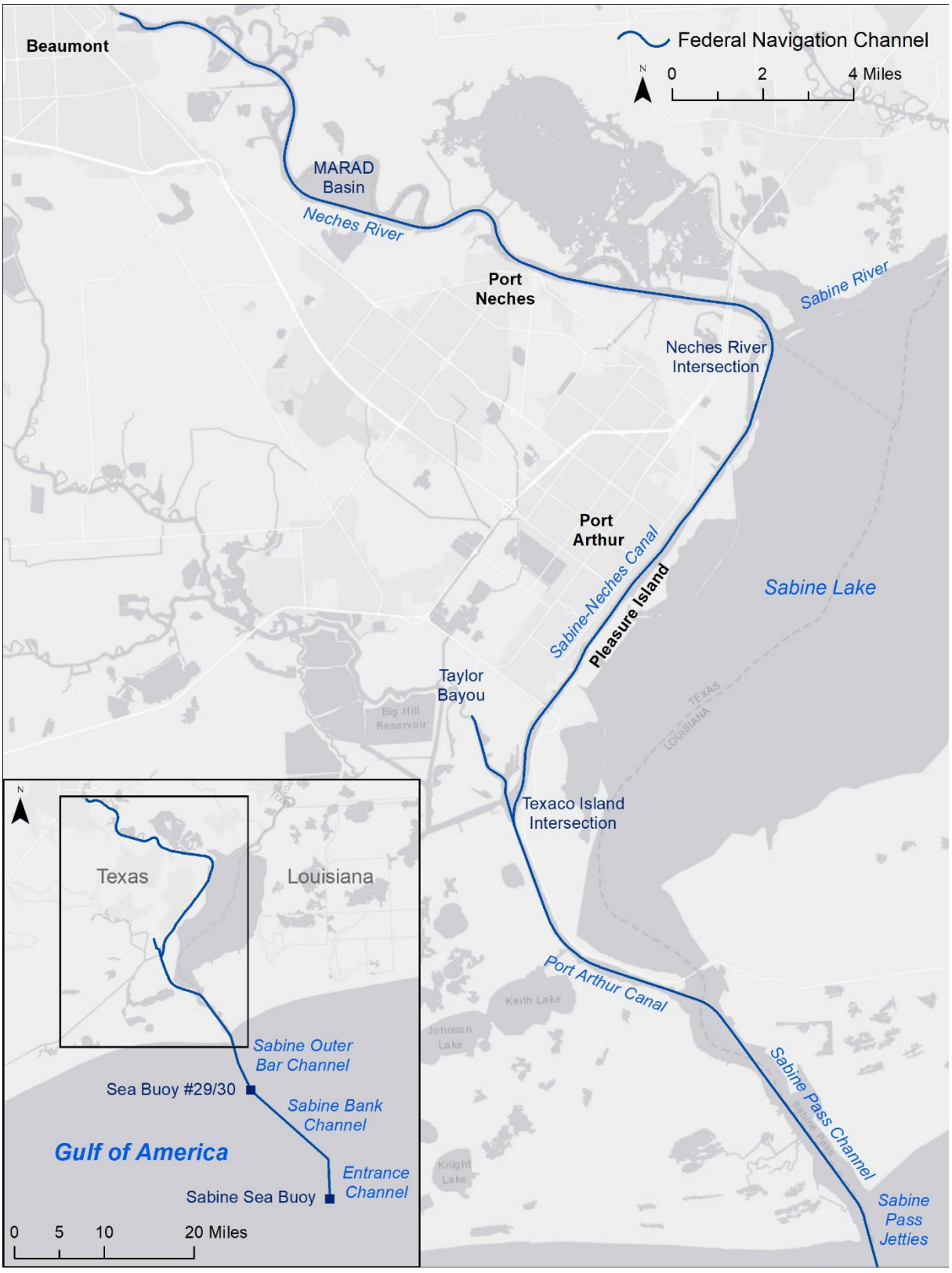
Mutable inputs into the Sabine Neches Congestion Model are the waterway configuration and vessel call lists. The waterway configuration includes the geospatial layout of features and associated attribute data for those components of the waterway to be navigated by vessels in the traffic simulator. Waterway features include channels, docks, turning areas, and anchorages. Vessel call lists identify each vessel (and associated relevant attributes) to transit the waterway for a modeled year. Additional static model inputs include weather delays and astronomical tables for sunrise and sunset times.

1.1 Waterway Configuration

The Sabine Neches Waterway (Figure 1) is currently being deepened from 40 to 48 feet[1] based on a Channel Improvement Project (CIP) Feasibility Study and Final Environmental Impact Statement (FS/FEIS) that was completed in 2011 (USACE, 2011a). Construction of the channel deepening is ongoing and projected to be completed in seven to 10 years. When completed, the channel deepening will move the channel entrance from the Sabine Sea Buoy to a location more than 13 miles farther offshore. The geographic representation of the waterway and associated port facilities was mapped using GIS software and consists of channels, docks, turning areas, and anchorages. The following sections detail the waterway configuration assumptions and the parameters that could be varied to evaluate the alternatives.

[1] MLLW – mean lower low water, the average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

Figure 1
Overview of the Sabine-Neches Waterway and Channel Reaches

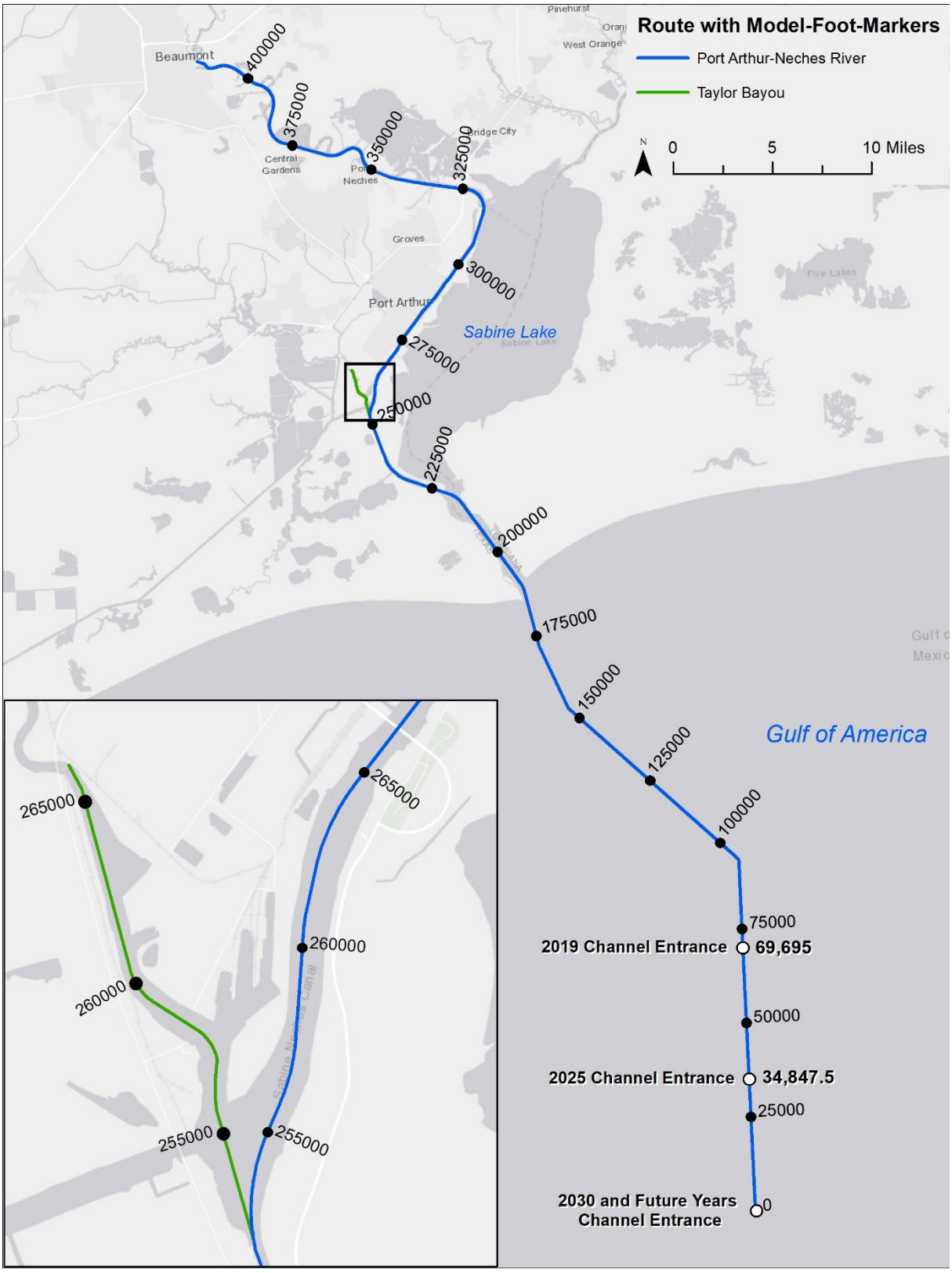


1.1.1 Channels

The federal navigation channel is measured in feet from the entrance of the fully deepened channel in the Gulf of Mexico to the Neches River upstream of the Port of Beaumont, including a fork allowing access into Taylor Bayou (Figure 2). Within the model, channel length, width, and depth are variable parameters that may be altered to reflect the existing condition, future without-project condition, and the alternative channel geometries evaluated in the analysis.

As depicted in Figure 2, the waterway is represented using two distinct "routes" with model foot markers depicting the distance from the 2030 and future years channel entrance. The Taylor Bayou Route provides access to those docks within Taylor Bayou and the Port Arthur-Neches River Route provides access to those docks above Texaco Island. The channel below the intersection at Texaco Island is shared by both routes.

Figure 2
Model Routes in the Sabine-Neches Waterway



In model runs using 2019 channel geometry, channel depth is -40 feet MLLW and the beginning of the Federal channel is located at the current location of the Sabine Sea Buoy (model-foot-marker 69,695). Based on the ongoing channel deepening plan for construction, which assumes the deepening to be performed in two, four-foot deepenings, the model runs for 2025 assume a 44-foot channel depth. As such, the channel entrance under the 2025 model runs begins at model-foot-marker 34,847.5. Model runs for 2030 and future years assume the ongoing channel deepening construction has been completed and therefore has a 48-foot channel depth. Within the 2030 model runs and thereafter, the channel entrance begins at model-foot-marker 0 as depicted in Figure 2 and shown in Table 1. Figure 2 depicts the three locations of the channel entrance over the modeling period of analysis.

Table 1
Model Channel Depth and Entrance Channel Location Over Time

Modeled Year	Assumed Depth (ft MLLW)	Entrance Channel Location (ft)
2019	40	69,695
2025	44	34,847.5
2030 and thereafter	48	0

Future without-widening condition channel widths are equivalent to existing condition channel widths, with the exception of the Sabine Bank Channel that will be reduced from 800 feet to 700 feet as a part of the ongoing CIP. Future with-widening channel widths can be varied in alternative model runs to assess the effects on traffic flow. The length and specific location of widened reaches are also variable within the model. Table 2 shows the waterway reaches where widening was considered and the modeled widths used within those reaches. The waterway reaches are depicted in Figure 1.

Table 2
Modeled Channel Reach Widths

Waterway Reach	**Existing Width (ft)**	**Modeled Widened Widths (ft)**		
Sabine Pass Channel	500	500	600	700
Port Arthur Canal	500	500	600	700
Sabine-Neches Canal	400	500	600	700
Neches River Channel	400	500	600	700

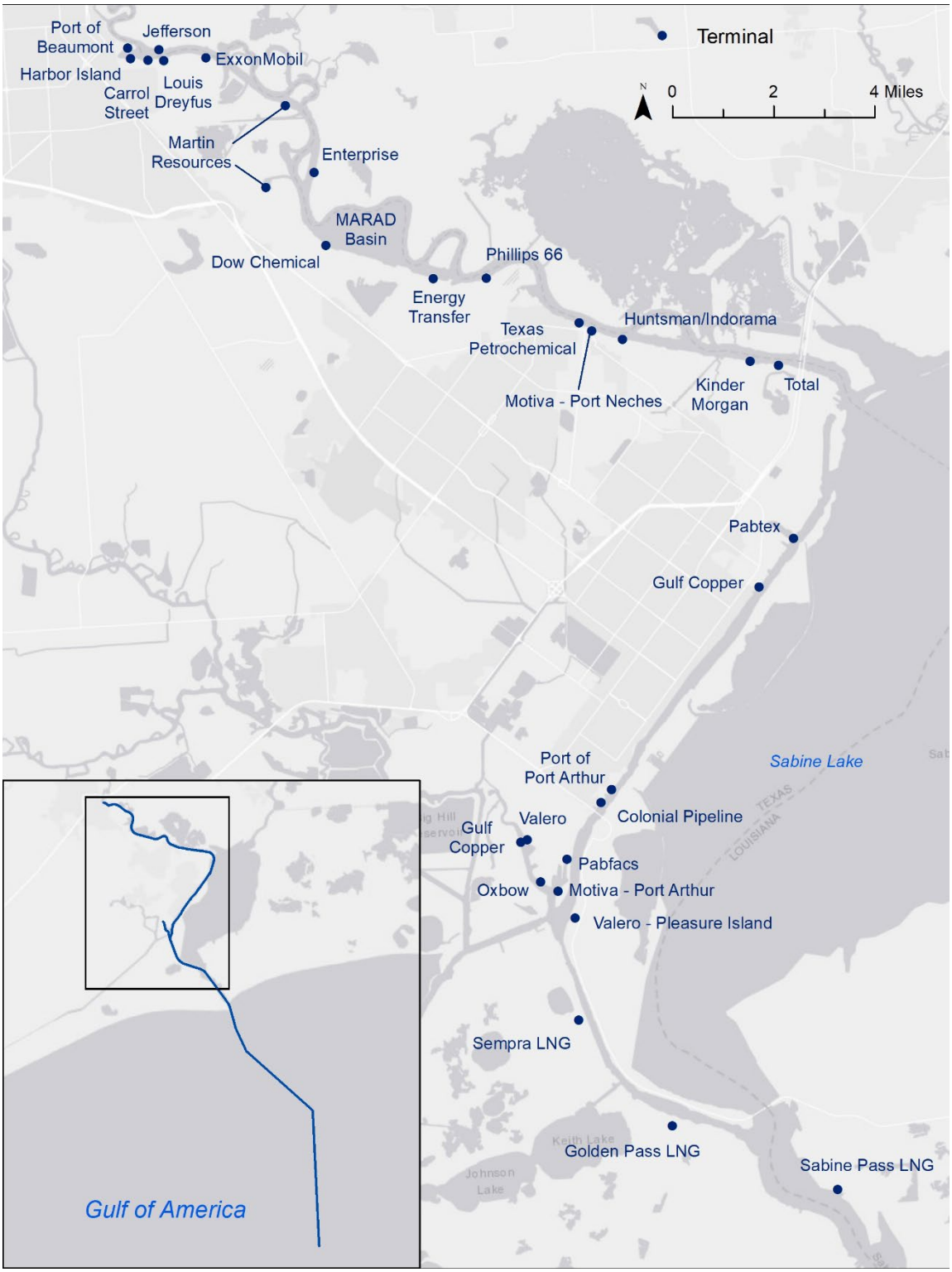
1.1.2 Docks

Figure 3 shows the terminal locations on the Sabine-Neches Waterway where one or more docks service deep draft vessels and barges. The dock property parameters within the model include the dock name, route, and model-foot-marker (i.e., the channel distance from the channel entrance in the Gulf of Mexico to the respective docks). As such, each dock is situated at a unique location within the waterway in the vessel traffic simulator. Additional dock properties within the model include the vessel type and commodity type(s) accommodated at the dock and the commodity-specific transfer rate at each dock; these data are a function of the specific dock facilities and infrastructure[2]. Commodity tonnage and transfer rates are used to determine the work-time duration of a dock visit within the vessel call list. For all docks, the dock berth controlling depth is identical to the adjacent channel depth in keeping with the CIP deepening project.

In addition to these data about current dock operations, terminal operators provided information on projected future use of their docks, including projected number and size of vessels to be visited by year, dock modifications, and future dock construction. Model output for future years was analyzed for docks with exceptionally high utilization (docks that were claimed or occupied more than 80% of the time) that were causing unacceptably long delays (e.g., vessels waiting at sea for more than a week without a weather delay). Delays were caused by appropriately including the forecasted vessels to visit the docks associated with a terminal in the vessel call list; however, the terminal capacity was insufficient to receive the number of vessels in the provided forecast without a change to the terminal docks. At some terminals, an additional dock was included in a vessel's choice set by the modeler (either as modification of underutilized existing docks to accommodate additional vessel types or as construction of a new dock adjacent to or near to existing terminal facilities) to reduce vessel delays attributable to exceptionally high dock utilization rates. This adjustment was made to better reflect likely future conditions.

[2] Specific dock facilities, infrastructure, commodities, and transfer rates, as well as future dock use and construction, were obtained from terminal operators under non-disclosure agreements.

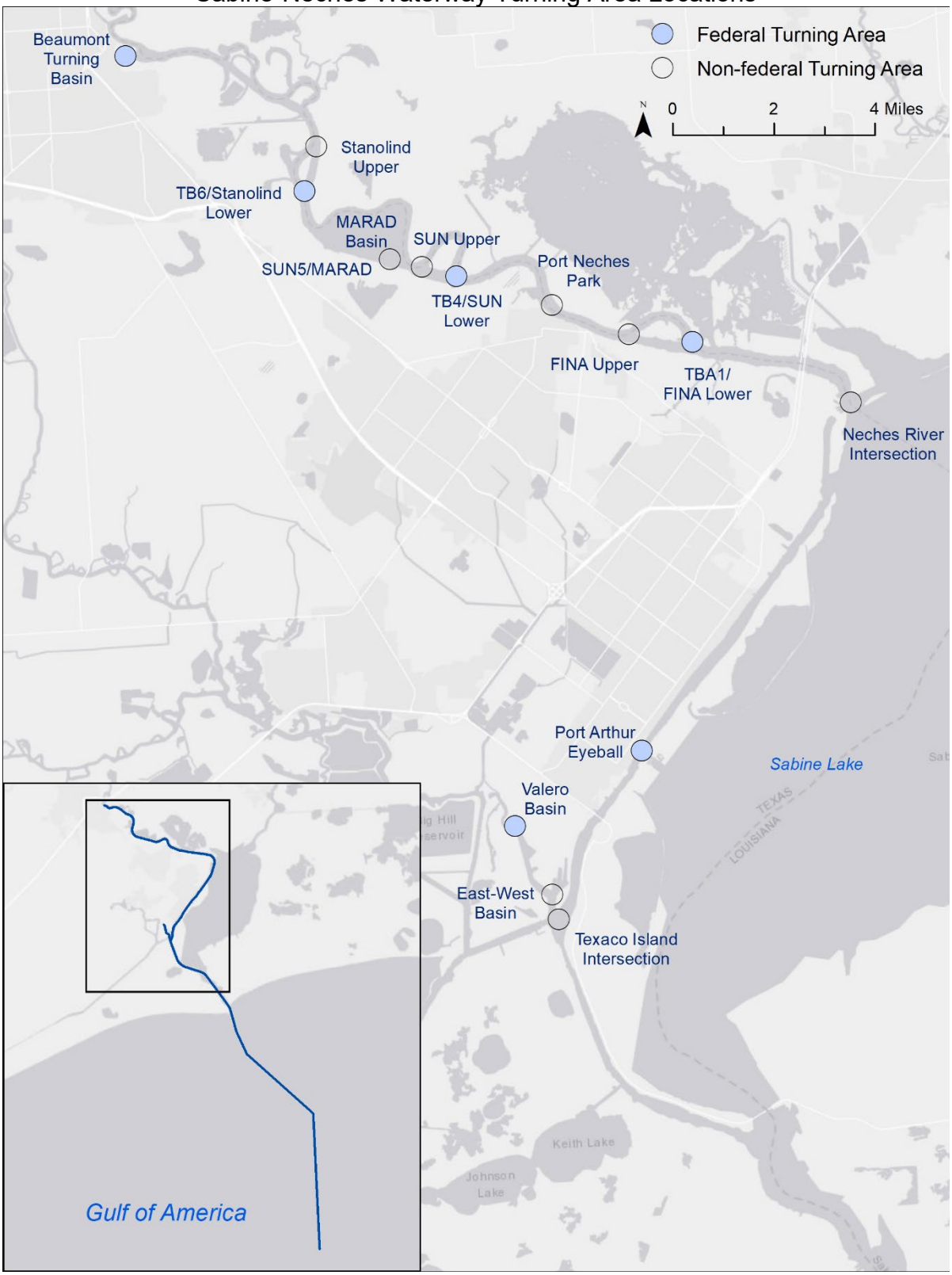
Figure 3
Deep Draft Terminal Locations on the Sabine-Neches Waterway



1.1.3 Turning Areas

Turning areas in the Sabine-Neches Waterway are used to turn light-loaded vessels as is standard operating procedure on the waterway. There are 14 turning areas, including six Federal turning areas and eight non-federal turning areas (Figure 4). All turning areas exist in both the existing condition and all future conditions. Turning area properties include name, route, and model-foot-marker. In addition, the maximum vessel length and maximum vessel deadweight tonnage are properties assigned to each turning area used to determine whether a vessel may use a turning area. Turning area depth is coincident with channel depth in the current condition and future conditions (i.e., 40 ft deep in 2019, 44 ft deep in 2025, and 48 ft deep in 2030 and later years). The assumed pilot usage of turning areas for specific dock destinations (i.e., dock-turning area associations) that were used in the model were verified with the Sabine Pilots.

Figure 4
Sabine-Neches Waterway Turning Area Locations



1.1.4 Anchorages

The waterway configuration within the model includes seven anchorages in the Sabine-Neches Waterway (three Federally authorized and maintained; four privately held), all of which are in the Neches River (Figure 5). Anchorage properties include name, route, model-foot-marker, and controlling draft, such that only those vessels with a current draft less than or equal to the controlling draft may use the anchorage. In-bound vessels may go to an anchorage and wait for the appropriate dock to be vacated. As verified with the Sabine Pilots, this practice occurs regularly on the waterway and allows vessels to avoid being delayed further by the daylight restrictions. Vessels do not typically go from a dock to an anchorage for the purpose of freeing up the dock for another vessel. Doing so may be advantageous to the terminal operator, but it is expensive for the vessel because it creates two separate vessels movements each requiring tugs and pilots. Anchorage access in the SNTS is given on a first-come-first-served basis. The minimum time at anchorage is assumed to be four hours, based on an examination of the US Coast Guard's Vessel Traffic Service anchorage usage data, but is a configurable setting within the SNTS.

Anchorage basins Sun Anchorage Lower and Sun Anchorage Upper are owned, maintained, and operated by Energy Transfer. The depth of Sun Anchorage Upper coincides with current channel depth (-40 feet MLLW), whereas the depth of Sun Anchorage Lower is maintained at -38 feet MLLW. It is assumed that the depth of Sun Anchorage Upper will continue to coincide with the channel depth in future years and the depth of Sun Anchorage Lower will continue to be two less feet than the channel depth (i.e., -42 feet MLLW in year 2025 and -46 feet MLLW in years 2030 and thereafter). Although Energy Transfer operates the Sun anchorages and has discretion over which vessels may use these anchorages, possibly giving preference to vessels using the Energy Transfer terminal, the SNTS does not give preferential anchorage access to any vessels.

Anchorage basins Fina Anchorage Upper and Stanolind Anchorage are not maintained and have depths of 28 feet and 22 feet, respectively. These depths are not altered in future model years, despite channel deepening.

Which anchorages are available for use varies depending on the model year. Turning Basin Anchorage 1, Anchorage Basin 4, and Anchorage Basin 8 are to be constructed as features of the ongoing CIP construction. As such, they did not exist in 2019 and any 2019 model runs do not include them as available anchorages. Model years after 2019 include the anchorages at the channel depth at that model year (i.e., -44 feet MLLW in year 2025 and -48 feet MLLW in years 2030 and thereafter). In addition, the SNTS contains a toggle to allow the existence of only Turning Basin Anchorage 1, but not Anchorage Basin 4 or Anchorage Basin 8. This was created to assess the impact of the construction of only Turning Basin Anchorage 1. Finally, at the time of model design, the capacity of Anchorage Basin 4 was still being evaluated. Accordingly, the SNTS may be configured so that Anchorage Basin 4 can hold up to four vessels at a time.

Figure 5
Sabine-Neches Waterway Anchorage Locations

1.1.5 Ancillary Datasets

Additional tabular datasets used in the model to represent the physical setting and environment of the waterway are weather and the times of sunup and sunset (i.e., daylight) each day. The SNTS determines whether it is daylight according to astronomical tables for Port Arthur, TX.[3] Dawn and dusk times vary throughout the year and according to the definition of daylight used.

As described in Section 2.1.5 of this appendix, a statistically equivalent synthetic year of weather events was created using weather delay data from 2007 to 2019. This synthetic record of weather delays was used for all SNTS simulations.

1.2 Vessel Call Lists

The vessel call list identifies each vessel transit through the waterway for a modeled year. As such, the 2019 vessel call list is built from substantial data on actual vessel transits that occurred in 2019 and is the basis for all future call lists. Vessel call lists for 2025 – 2050 are developed from the 2019 vessel call list by adding or removing cargo or vessel calls as guided by the commodity and fleet forecasts (discussed below). The 2019 vessel call list is the accumulation of observed and recorded data for each deep draft vessel and articulated tug-barge (ATB) call. Data from four different sources, as detailed below, was used to time stamp vessel movements, quantify cargo loads, and identify dock and anchorage usage for each vessel call in 2019.

1.2.1 2019 Vessel Call List Development

The data sources for the 2019 vessel Call List are listed below, briefly introduced, and referenced throughout the remainder of this Section in technical discussions.

- Port Import/Export Reporting System (PIERS), is a commercially-available database of import and export data at the detailed, bill-of-lading level, which mirror data that are filed with U.S. Customs. PIERS data from 2019 and specific to the Sabine Neches Waterway were acquired from S&P Global[4] and then used as the first step in establishing import and export cargo volumes. PIERS data include the following cargo information:
    - Cargo designation of export or import
    - Date of cargo transfer from or to a vessel
    - Foreign country of cargo origin or destination
    - Cargo commodity group, codes, and descriptions
    - Cargo quantity and units of measure (non-weight based)
    - Cargo weight
    - Vessel IMO number
    - Vessel name
- Confidential Cargo Data were requested and voluntarily provided by 13 Sabine Neches Waterway terminal operators, most under signed non-disclosure agreements, in order to establish refined volumes of import and export cargo volumes. In addition to verifying (and at times, correcting) PIERS foreign cargo volumes and/or tonnages, the individual

[3] https://www.timeanddate.com/sun/@7174113?month=1&year=2019
[4] https://www.spglobal.com/marketintelligence/en/mi/Info/1115/piers-enterprise-solutions.html

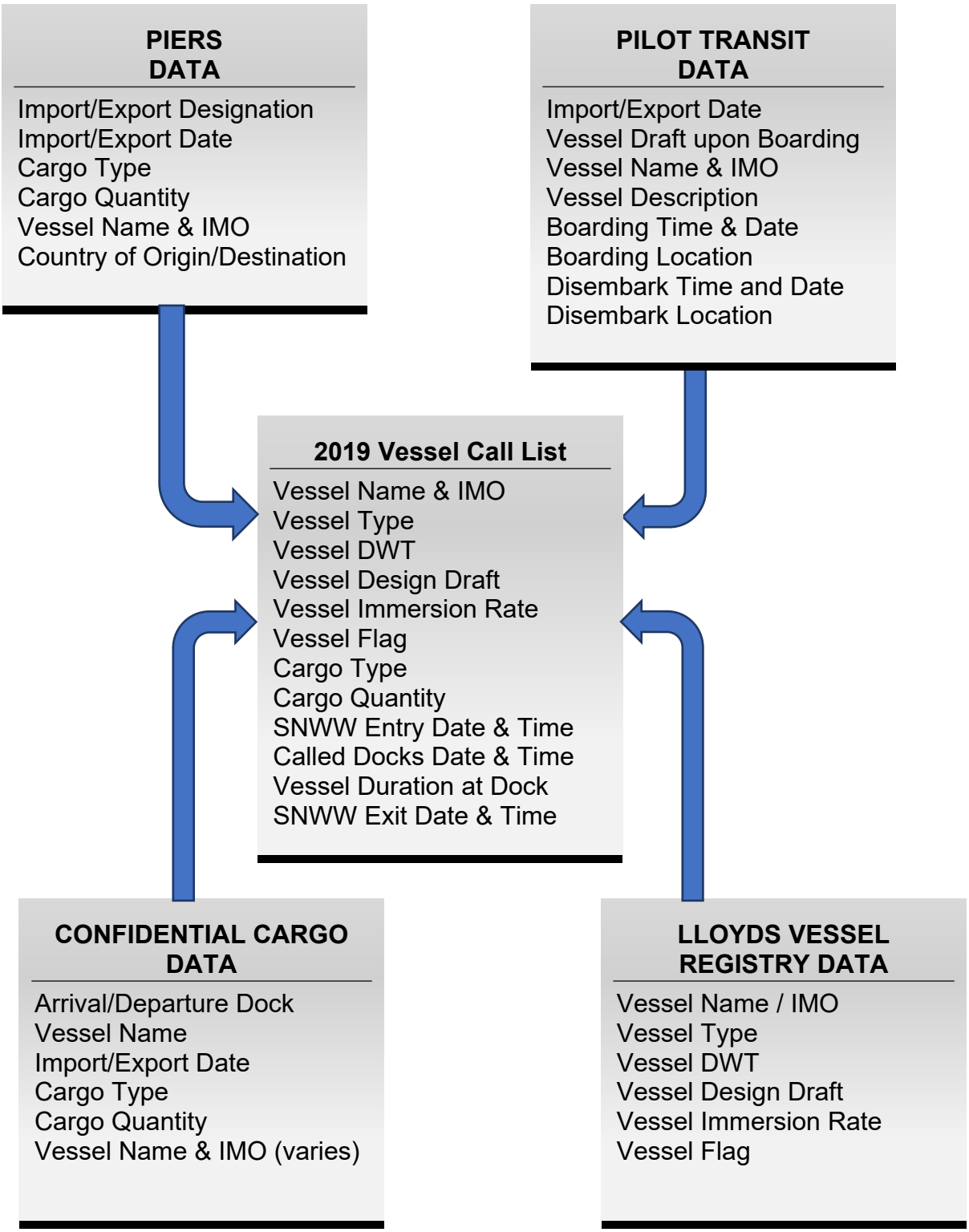
terminal data contained information on domestic cargo volumes, which is absent from PIERS data.

- Sabine Pilots Vessel Transit Data provide vessel movement data for all vessels requiring pilot assistance for the years 2018 and 2019. Each vessel movement is contained in a single record (or row) in the data provided by the Sabine Pilots. For example, one record will provide data on the vessel's movement from open water to an anchorage, and a separate record will provide data on the vessel's movement from the anchorage to a dock, and a final record will provide data on the vessel's movement from a dock back out of the Sabine-Neches Waterway. The Sabine Pilots vessel transit data include:
    - Vessel Name
    - Vessel Description
    - Vessel IMO number
    - Vessel Call Sign
    - Vessel Draft upon boarding
    - Location and time at which a pilot boarded a vessel
    - Location and time at which a pilot disembarked a vessel
- Lloyds List Intelligence, is an on-line subscription database used to gather information on the existing and future projected fleet of crude oil vessels (i.e., vessel deadweight tons (DWT), immersion rate, design draft, vessel liquid capacity volume).

Blending of the four data sets (see Figure 6) creates a comprehensive list of distinct vessel movements carrying a specific type and amount of cargo to or from a dock within the waterway during 2019. Each vessel call begins at a specified date and time at the channel entrance, as noted by the Sabine Pilot's data. The vessel name, IMO, type, draft, and destination dock are cross referenced from multiple data sets. Vessel characteristics are based on Lloyds List Intelligence data for self-propelled vessels, and VTS data for articulated tug-barge units. Cargo type, tonnage, and import, export or domestic designation are also cross referenced with PIERS and the confidential cargo data supplied by the terminal operators.

The 2019 vessel call list tonnage (128.3 million short tons) is within 2.6% of the 2019 Sabine Neches Waterway cargo tonnage (125.1 million short tons) as identified in the 2019 USACE Waterborne Commerce Statistics. Cargo transfer rates and working time at the dock are based on terminal records or estimated from terminal records and confirmed by personal communication with the terminal operators. Vessel departure time and departure draft are based on pilot's data cross referenced with terminal data. If necessary, drafts were calculated using the vessel's Long Tons per Inch Immersion (e.g., the weight of cargo in long tons to change the draft one inch) using the formula TPI = (((Vessel LOA in feet * Vessel Beam in feet) / 420) * 0.89). This formula was compared to the average listed TPI of 300 tankers and was off by one-tenth of one percent.

Figure 6
Databases Used in Development of 2019 Vessel Call List



1.2.2 Vessel Call Lists for Years 2025 – 2050

In order to establish future year vessel call lists, a commodity forecast and fleet forecast are used to create a vessel call list in future years by scaling from a known base year.

The 2019 vessel call list was used as the base year template for future-year vessel call lists. The commodity forecast and the fleet forecast were used to adjust the 2019 vessel call list for future years. Additionally, future-year vessel call lists include a dock choice set for each vessel call and randomized vessel arrival times. Each future-year vessel call list begins in November of the previous year so the modeled year (01Jan – 31Dec) does not begin with an empty waterway. This adjustment better reflects reality and increases the number of vessels in the system during the first week of the year by nearly 50%. All model output and post-processing excludes the previous year's November and December traffic.

The commodity forecast incorporates national import and export forecasts published in the Energy Information Administration's (EIA) Annual Energy Outlook (February 2021) and individual forecasts by terminal operators. Non-hydrocarbon commodities (3.7% of total waterway cargo in 2019) were assumed to have no growth throughout the period of analysis.

Future-year vessel call list commodity tonnage was generated by applying the appropriate growth rate (for commodity type, year, and direction of trade) to cargo identified in the 2019 vessel call list. Changes to 2019 cargo tonnage was applied terminal-by-terminal with the intention of using available capacity in the existing fleet calling at each terminal prior to adding additional vessels. Additional cargo, if any, as identified by the commodity forecast in future years was loaded onto vessels in the 2019 vessel call list according to commodity type, terminal, trade direction and vessel type.

Vessel loading is based on the vessel's 2019 cargo tonnage, loaded draft, immersion factor, draft capacity, and volumetric capacity. Note that channel depth (assumed to be -44 feet in 2025 and -48 feet in 2030 given the ongoing channel deepening construction) constrains vessel loading for large deep draft vessels. If a vessel reached a capacity constraint, available capacity on another vessel with the same commodity type, terminal, trade direction and vessel type combination was used. If there was no such capacity available, then capacity on the next largest vessel type that met the same commodity type, terminal, and trade direction was assigned.

Commodity forecasts provided by individual terminal operators, based on planned terminal improvements, were used to add additional cargo to the commodity forecast and to add additional vessels to the fleet forecast.

Table 3 shows the growth rates calculated from the 2021 Annual Energy Outlook (2021 AEO) in five-year increments. Table 4 shows the national tonnages for each 2021 AEO commodity category used in this analysis. Table 5 provides the national increase or decrease in commodity tonnages in five-year increments. Table 6 presents the SNWW commodity tonnages used in this analysis, and Table 7 presents the SNWW increase or decrease in commodity tonnages in five-year increments.

Table 3
Five-Year Annual Percentage Growth Rates from 2021 AEO

Commodity	2025*	2030	2035	2040	2045	2050
Crude Oil Gross Imports	1.3	-1.6	0.1	1.4	-0.6	1.0
Crude Oil Exports	2.7	-1.2	0.8	-0.3	-0.9	0.4
Gross Refined Product Imports	-5.6	2.9	-0.2	0.5	0.7	-0.3
Refined Product Exports	4.3	0.4	-0.9	-0.4	-0.9	-1.5

*2025 represents a six -year growth rate from 2019 to 2025
Source: 2021 Annual Energy Outlook (February 2021)

Table 4
National Tonnages for Select 2021 AEO Commodities
(Metric Tons x 1000)

Commodity	2025	2030	2035	2040	2045	2050
Crude Oil Gross Imports	379,651	349,928	351,032	376,385	365,867	384,383
Crude Oil Exports	158,383	148,878	154,664	152,395	145,814	148,684
Gross Refined Product Imports	28,770	33,132	32,809	33,653	34,830	34,330
Refined Product Exports	336,631	344,136	328,527	321,203	307,423	284,969

Calculated from 2021 Annual Energy Outlook (February 2021)

Table 5
2021 AEO National Tonnage Estimates 5-Year Incremental Change
(Metric Tons x 1000)

Commodity	2025	2030	2035	2040	2045	2050
Crude Oil Gross Imports	53,438	21,133	-15,575	-27,579	-9,344	-6,527
Crude Oil Exports	74,493	-29,723	1,104	25,353	-10,518	18,516
Gross Refined Product Imports	5,207	-9,506	5,787	-2,269	-6,582	2,870
Refined Product Exports	-15,093	4,362	-323	844	1,177	-500

Calculated from 2021 Annual Energy Outlook (February 2021)

Table 6
Sabine-Neches Waterway Commodity Tonnages Used in Traffic Model
(Metric Tons x 1000)

Commodity	2025	2030	2035	2040	2045	2050
Crude Oil Imports	22,124	20,180	19,974	20,653	20,760	21,037
Crude Oil Exports	47,384	45,337	45,535	44,334	42,572	42,657
LNG (Export)	43,913	65,657	65,657	65,657	65,657	65,657
LPG (Export)	18,813	18,920	18,828	18,673	18,601	18,469
Product & Related Imports	2,559	1,978	2,112	2,483	2,617	2,731
Product & Related Export	39,904	40,808	39,149	37,935	36,991	35,955
Not Oil &Gas Related	4,268	4,266	4,266	4,266	4,266	4,266
Total	**178,965**	**197,146**	**195,521**	**194,002**	**191,464**	**190,773**

Table 7
Change in Sabine-Neches Waterway Commodity Tonnages (5-Year Increments)
(Metric Tons x 1000)

Commodity	2025	2030	2035	2040	2045	2050
Crude Oil Imports	2,211	-1,944	-207	679	108	277
Crude Oil Exports	16,419	-2,048	199	-1,201	-1,763	86
LNG (Export)	20,990	21,744	0	0	0	0
LPG (Export)	13,731	107	-93	-155	-73	-131
Product & Related Imports	-930	-580	134	371	134	113
Product & Related Export	10,154	904	-1,659	-1,214	-944	-1,037
Not Oil &Gas Related	1	-2	0	0	0	0
Total	62,576	18,181	-1,625	-1,519	-2,538	-692

2025 represents a six -year growth rate from 2019 to 2025

1.2.3 Fleet Forecast

The fleet observed in the Sabine-Neches Waterway in 2019 was used to establish the 2019 vessel call list (as described in Section 1.2.1 of this appendix) and provides the basis for the future years' fleet forecast. The commodity growth as forecasted in the 2021 AEO was distributed to the 2019

fleet. All vessels added due to individual terminal operator projections were also based on the 2019 vessel call list so that added vessels matched physical and operational characteristics of vessels that called at each respective terminal in 2019. The 2019 vessel call list, because it displays the exact date and time of arrival and departure, identifies a scheduling patterns for each dock. All added vessel calls were inserted into future-year vessel call lists with arrival dates that mesh with the 2019 scheduled vessel arrivals to avoid schedule conflicts. In future year vessel call lists, the time of arrival at the sea buoy is randomized by adding a randomly selected amount of time between 0 and 12 hours. Table 8 displays the actual number of vessel calls by vessel class for 2019 and the forecasted fleet and commodities for each subsequent modeled year.

In addition, vessels in future year vessel call lists have a choice set of docks that may be used at each terminal. At terminals, dock choice sets range from one to three docks, depending on terminal, commodity type, and vessel type. If high rates of berth utilization were found to cause delays, additional docks were added to a terminal or dock attributes were modified to allow handling of multiple commodities. In this manner, hours in the system calculated by the SNTS were not unduly influenced by high berth utilization rates that would likely be addressed by the terminal operators.

Table 8
Vessel Calls by Vessel Class for 2019 and Modeled Years

	2019	2025	2030	2035	2040	2045	2050
Aframax Tanker	549	595	595	595	595	595	595
Aframax Bulk	7	7	7	7	7	7	7
ATB	328	326	326	326	326	326	326
Handy Bulk	237	237	237	237	237	237	237
Handy Tanker	179	178	178	178	178	178	178
LNG	336	643	961	961	961	961	961
Long RORO	4	4	4	4	4	4	4
LPG	136	420	420	420	420	420	420
Panamax Tanker	806	1,008	1,008	1,008	1,008	1,008	1,008
Panamax Bulk	187	187	187	187	187	187	187
Pmax RoRo	36	36	36	36	36	36	36
Suezmax	99	245	245	245	245	245	245
TOTAL	**2,904**	**3,886**	**4,204**	**4,204**	**4,204**	**4,204**	**4,204**

2 Description of Model Processing

The Sabine-Neches Traffic Simulator engine uses a decision tree to evaluate the status and movement of all vessels in the vessel call list at each timestep in the simulation. The SNTS is built from a group of components that together implement the model logic. Each component is identified below and its function in model implementation is described.

2.1 SNTS Parameters

SNTS modeling parameters are implemented to define the spatial and temporal variables impacting a simulation.

2.1.1 Timestep

The simulator implements a time series used to track vessel movements through the waterway over the simulation duration. The fundamental unit of time is the timestep, a configurable value measured in integer minutes. Early in model development, timestep values of 30 and 15 minutes were experimentally investigated. It was determined that the 30 minute timestep did not provide sufficient detail and 15 minutes was too close to the amount of time required to capture the turning of vessels. A 5-minute timestep was briefly assessed but was deemed overly burdensome and redundant. The model timestep used throughout the analyses is 10 minutes, such that all vessels and associated navigation conditions are assessed and documented in 10-minute intervals throughout the full simulation duration.

2.1.2 Simulation Duration

Each model simulation has a begin date and an end date, as defined by a starting date and the number of minutes to simulate. The model analysis period begins January 1 at 00:00 and a duration of 525,600 minutes (one year); however, as mentioned previously, in order to avoid model simulations beginning with an empty waterway, an additional two months of model simulation (November and December of the previous year) are used to simulate a fully loaded waterway at the time of model initiation. As such, the full simulation duration is 613,440 minutes but all analyses of model output are restricted to only one year (January 1 through December 31).

2.1.3 Channel Entrance Location

A vessel transit begins when a vessel "arrives" at the channel start location according to the arrival time provided in the vessel call list; however, given the traffic and weather conditions in the waterway at the arrival time, the vessel may be required to wait at sea before entering. Waiting at sea is a common occurrence and there are multiple offshore areas where a vessel may wait. Neither the vessel call list nor the SNTS designates where the vessel might wait. In the SNTS, vessels waiting at sea are assumed to be waiting at the channel entrance and are immediately available to enter the channel when the conditions permit. Time accrued traversing from an offshore waiting location to the channel entrance is not accrued as a part of the vessel transit. All vessel transits are initiated and completed at the channel entrance.

As described in Section 1.1.1 of this appendix, the Sabine-Neches Waterway is presently deepening the existing channel. As a result of this deepening, the channel entrance will be extended approximately thirteen miles further into the Gulf of Mexico upon completion. The waterway geometry and associated features are measured in feet from the endpoint of the fully constructed channel in the Gulf of Mexico. Therefore, the location of the channel entrance, i.e., the footage mark of the channel from which vessels enter the channel, varies depending on the model year used in the simulation. As depicted in Figure 2, simulation year 2019 uses the present channel entrance location (foot-marker 69,695). Simulation year 2025 uses a location midway between the 2019 location and the final channel entrance location (foot-marker 0), which is used as the channel entrance for all subsequent model years.

2.1.4 Channel Widths

Existing channel widths are a part of the port configuration; however, the existing channel width may be overridden within the SNTS to create with-widening conditions, such that one or more reaches of the waterway is modified according to project alternatives within the simulation.

2.1.5 Weather

Weather delays due to fog or high seas are a common occurrence during the winter months in the Sabine-Neches Waterway and must be included in the simulations when modeling vessel traffic.

Weather delays are implemented in the model so that all vessels that are in motion or attempting a move (e.g., entering the waterway, departing a dock, or departing an anchorage) are held in their present position and may not resume their voyage until the end of the weather delay. During a weather delay, vessels transferring cargo or bunkering[5] when the weather delay begins will continue those operations unimpeded (e.g., vessels at dock continue to accrue dock working time associated with commodity transfer and vessels at anchorage continue to accrue anchorage time associated with bunkering). Once a weather delay has elapsed, vessels in motion prior to the delay resume their movements within the waterway. The process of recovering from a weather event is to complete the voyage for all vessels delayed due to the weather event and any additional vessels queued at sea created due to the delayed voyages of vessels already transiting the waterway. Although the identical weather events would impact vessels in both the with- and without project conditions, the duration of time required for the waterway to fully recover from the traffic delays occurring due to the weather event differs between the project alternative conditions.

For SNTS simulations, a statistically equivalent synthetic year of weather events was created using weather delay data from 2007 to 2019. This synthetic record of weather delays was used for all simulations.

2.2 SNTS Constraints

SNTS modeling constraints are values or toggles implemented within a simulation to restrict vessel movements within a simulation.

2.2.1 Vessel Speed

All simulated vessels transiting the waterway abide by the same speeds. Those vessels in the entrance channel, but outside the jetty tips, travel at 12.0 knots, whereas vessels anywhere inside the jetty tips and up to the Port of Beaumont travel at 6.0 knots. Using consistent travel speeds for all vessels ensures that in the model no vessels overtake another vessel traveling in the same direction, which is consistent with standard operating procedures for the waterway. These values can be changed within the SNTS, but all simulations used these values.

2.2.2 Daylight Restrictions

According to the Sabine Pilots Association operations protocols (SPA, 2009), vessel movement within the Sabine-Neches Waterway is currently restricted to daylight-only for vessels moving above Texaco Island (Figure 1) if the vessels have a deadweight tonnage greater than 85,000, have

[5] Bunkering is the supplying of fuel to a vessel. Such fuel is referred to as bunker.

a length overall of 875 feet or greater, or have a beam of 125 feet or greater, (i.e., Aframax and Suezmax vessels). Of the vessels 2,904 deep draft vessels that transited the SNWW in 2019, 985 of them were daylight restricted.

Within the model, the SNTS determines whether it is daylight according to astronomical tables for Port Arthur, TX[6] as described in Section 1.1.5 of this appendix. Dawn and dusk times vary daily and according to the definition of daylight used. The simulator can use the definitions of civil daylight, nautical daylight, or astronomical daylight, with the default setting of nautical daylight. Furthermore, the location of the beginning location for the daylight-only restriction can be configured to a location other than Texaco Island. The determination of the daylight status occurs at each timestep.

The pilotage rules permit moving a daylight-restricted vessel between docks and nearby anchorages at night. The definition of nearby is not provided in the pilotage rules; however, consultation with the Sabine Pilots provided operational guidance, such that vessels below the Neches River Beacon 26A may move to another point on the Neches River below Beacon 26A and vessels above Beacon 26A may move to another point above Beacon 26A, but not above Stanolind Anchorage (see Figure 5). These Pilot practices are included in the SNTS.

2.2.3 Vessel Meetings

Before initiating a vessel movement, the SNTS determines if the vessel attempting to move will meet an oncoming vessel within the waterway. If an oncoming vessel will be met, the channel dimensions at the location of the predicted meeting and the characteristics of both vessels are used to determine if the meeting will be permitted according to the pilotage rules. Figure 7 shows locations relevant to the meeting area restrictions listed below.

Under the current conditions of the SNWW, the following pilotage rules must be satisfied to permit a vessel meeting:

1. Vessels with a combined beam that equals or exceeds 1/2 the channel width will not meet day or night;
2. Vessels 85,000 metric deadweight tons or more will not meet vessels of either 30,000 metric deadweight tons or more, or 25-foot draft or more above Texaco Island intersection;
3. Vessels 85,000 metric deadweight tons or more will not meet vessels of 30,000 metric deadweight tons or more with a draft of 30 feet or more, above buoys 29 and 30;
4. Vessels 48,000 metric tons or more with a draft of 30 feet or more will not meet above buoys 29 and 30;
5. Vessels with a combined draft of 70 feet or more will not meet between the Neches River intersection and daybeacon #40 (Smith's Bluff) at night; and
6. Vessels with a combined draft of 65 feet or more will not meet above daybeacon #40 at night.

[6] https://www.timeanddate.com/sun/@4720039?month=1&year=2019

All pilotage meeting rules involving vessel drafts are unmodified in future conditions (i.e., after the ongoing channel deepening is completed), despite additional channel depth. This is in accordance with consultation with the Sabine Pilots who advised that a reasonable additional draft allowance cannot be assessed at this time and that a conservative assumption is that no additional draft for vessel meetings would be granted (see Appendix C).

Figure 7
Restriction Location Markers

2.2.4 Pilot Use

Pilots are used to navigate vessels through the waterway as identified in the Ship Traffic Operating Protocol for the Sabine-Neches Waterway (SPA, 2009). The number of pilots used by a vessel depends on vessel type and dimensions. Two pilots are used when piloting a vessel with a beam 120 feet or more or a length over all of 860 feet or more. Smaller vessels use one pilot. Of the 3,371 vessels in 2019, 1,255 required two pilots. Pilots are assumed to be available and ready when the vessel is ready to be underway, as such, the time it takes for the dispatch of a pilot and subsequent arrival at a vessel is not considered in the vessel traffic simulator. The SNTS tracks the number of pilots used at every timestep and can constrain the total number of pilots available for use. When the maximum number of pilots available is constrained in simulations and all pilots are occupied at a timestep, vessels must wait at dock or at sea until a suitable number of vessels using pilots complete their movements, thereby making additional pilots available.

The number of pilots available was not constrained in SNTS simulations.

2.2.5 Tug Use

The number and type of tugs (pusher tugs vs tractor tugs) used to guide vessels through the channel and at turning areas and docks varies with vessel characteristics and vessel's location within the channel. The SNTS tracks the number and type of tugs used at each timestep. Terminals with dedicated tugs are not considered when tracking tug usage. Tugs are used in the following situations:

- Two tugs are used during the 15 minutes prior to turning;
- Two tugs are used during turning;
- Two tugs are used during the first 60 minutes of dock time during the mooring process;
- Two tugs are used during the first 40 minutes of the unmooring process;
- One tug is used to accompany Aframax and Suexmax vessels transiting the channel above Texaco Island;
- Loaded vessels mooring at Pleasure Island Dock use three tugs.

The time it takes for a tug to arrive from a different location within the channel is not considered in the vessel traffic simulator. When the maximum number of each type of tugs available is constrained, vessels must wait at dock until the appropriate number and type of tugs are available. Inbound vessels arriving from the sea are not affected by the number of available tugs. When the number and type of tugs available during a simulation is unconstrained, the appropriate number and type of tugs are assumed to be available for use during the timestep when and where they are required.

Tug use was not constrained in SNTS simulations and any benefits from potentially decreased tug use in the with-project condition were not calculated.

2.3 SNTS Vessel Movements

The guidelines establishing how the SNTS initiates and subsequently processes a vessel move are a function of ordered, rule-based logical sequences as detailed below.

2.3.1 Rules for Initiating a Vessel Move

Prior to initiating a vessel move, either from sea, anchorage, or dock, the SNTS evaluates multiple factors to determine if the vessel may begin the move.

The following conditions must be met before a vessel can enter the waterway from the sea:

1. The waterway must not be closed due to a weather event;
2. There must be enough pilots available for the vessel if the number of pilots is constrained;
3. All vessels use the same point of entry into the waterway; therefore the point of entry must not already be occupied by a vessel. The minimum distance between vessels entering the waterway is 1.5 miles. Only one vessel may enter the channel during each timestep;
4. At least one dock capable of handling the vessel type and cargo type must be available at the appropriate terminal. If no docks are available, the vessel may be able to reach a nearby anchorage instead;
5. If daylight restrictions are in place, the vessel must be unrestricted; and
6. If the entering vessel will meet another vessel during the transit, the meeting must be permitted to occur according to the pilotage meeting rules.

The following conditions must be met before a vessel can leave an anchorage:

1. The vessel must have been at anchor for the minimum amount of time to allow for bunkering. Bunkering time is a parameter setting with a default value of 4 hours;
2. The waterway must not be closed due to a weather event;
3. If daylight restrictions are in place, the vessel must be unrestricted;
4. There must be enough pilots available for the vessel if the number of pilots is constrained;
5. There must be enough tugs available to move the vessel if the number of tugs is constrained;
6. The channel must be clear for one mile both upstream and downstream of the anchorage;
7. The vessel leaving the anchorage must not encounter other vessels moving within the waterway or, if the vessels will meet, the meeting is permitted to occur according to the pilotage meeting rules; and
8. If the destination for the vessel is a dock, at least one suitable dock at the terminal must be available.

The following conditions must be met before a vessel can leave a dock:

1. The vessel must have been at dock enough time to accommodate docking, commodity transfer, and undocking. This duration is specific to the commodity, quantity, and terminal used;
2. The waterway must not be closed due to a weather event;

3. If daylight restrictions are in place, vessel specifications must not exceed pilot restriction limits;
4. There must be enough pilots available for the vessel if the number of pilots is constrained;
5. There must be enough tugs available to move the vessel if the number of tugs is constrained;
6. The channel must be clear for one mile both upstream and downstream of the dock; and
7. The vessel leaving the dock, must not encounter other vessels moving within the waterway or, if the vessels will meet, the meeting is permitted to occur according to the pilotage meeting rules.

If all conditions are met, the vessel may proceed. If these conditions are not met, the vessel must wait at the current location (at sea, at dock, or at anchorage) until such time as the conditions permit a move. Once a vessel is in motion, only a weather event can halt progress.

2.3.2 Order of Vessel Movements within a Timestep

Vessels in the vessel call list with an arrival date prior or equal to the current timestep date that have not already exited the simulation are evaluated within each timestep. To accommodate pilot operating rules, the sequence of assessment is:

1. Vessels traveling within the waterway, either inbound or outbound, are processed first so that vessels underway continue to move;
2. Vessels at dock, from low model-foot-marker to high model-foot-marker within the waterway (e.g., a vessel at dock at downstream terminal, such as Sabine Pass LNG, is assessed prior to a vessel at dock at an upstream terminal, such as Enterprise);
3. Vessels at anchorage, in order of arrival date so that vessels that have been active in the waterway longest are given priority when determining if they can continue their transit (e.g., a vessel at Anchorage Basin 4 that is waiting for a dock to become available is assessed prior to a vessel at sea attempting to reach the same dock).
4. Inbound vessels at sea, in order of dock location, from high model-foot-marker to low model-foot-marker within the waterway (e.g., a vessel going to a terminal located upstream in the waterway, such as ExxonMobil, is assessed prior to a vessel going to a terminal downstream, such as Valero).

In accordance with Sabine Pilots operating guidelines, vessels exiting the waterway are given priority over those entering the waterway and vessels entering the waterway are queued such that vessels at the front of the queue are those vessels headed farthest upstream into the waterway. Vessels in the queue transit the waterway such that a group of vessels form a caravan of inbound or outbound vessels. This queue is a standard operating procedure dictated and used by the Sabine Pilots in the operation of the waterway. The order of operations within each timestep creates a system of vessel queuing and caravanning within the SNTS that mimics the operations used by the pilots. A minor distinction between inbound vessel queuing operations in the SNTS and the inbound queuing operations conducted by the Sabine Pilots is that in the SNTS operations, an inbound vessel is allowed to enter the channel when conditions are appropriate, regardless of how many other inbound vessels are waiting at sea. However, typical pilot operations state if a single

inbound vessel could enter the channel 30 or 60 minutes prior to the caravanning of other vessels, the single vessel would be made to wait until all vessels can caravan together. This induced delay provides operational efficiency for the pilots by limiting the number of trips for the pilot delivery vessel to vessels at sea and is consistent with the practices of the Sabine Pilots (see Appendix C).

2.3.3 Dock Assignment and Use

The ultimate vessel destination within the waterway is at a terminal; however, for some vessel and cargo types, as many as three different docks at a terminal (the dock choice set) may be plausibly used by the vessel. The actual dock to be used by the vessel is determined dynamically when the vessel meets the SNTS requirements to transit the waterway to the dock, either entering from the sea or leaving an anchorage and subsequently arriving at dock.

2.3.4 Turning Area Use

All vessels entering the waterway must turn around in a turning area to exit the waterway (see Figure 4). In accordance with the Pilots rules, loaded vessels arrive at dock in a "head in" orientation (will turn after visiting the dock) and light loaded vessels arrive at dock in a "head out" orientation (turns before visiting the dock). Light loaded vessels turn in the nearest upstream turning area capable of facilitating the overall length of the vessel. Vessels are assumed to occupy the turning area for thirteen minutes based on the average turning time provided by the Sabine Pilots (see Appendix C).

2.3.5 Anchorage Use – From Sea

If all suitable terminal docks are occupied at the time a vessel can enter the waterway from sea, the vessel may reserve and transit to a suitable unoccupied and unreserved anchorage (see Figure 5) according to the vessel's current draft. Since all anchorages are capable of holding the largest vessels transiting the waterway, vessel length was not considered. If multiple anchorages are available, the anchorage closest to the destination dock is chosen. Once a vessel arrives at the destination anchorage, it must occupy the anchorage for a minimum amount of time to accommodate bunkering. The minimum time at anchorage is configurable, with a default value of four hours. The default value of four hours was determined by assessing historical anchorage use records provided by the US Coast Guard Vessel Traffic Services (VTS) data and confirmation with Pilot's experience. This minimum anchorage use time also avoids overly opportunistic use of anchorages, such as staying at anchorage for much less than four hours before proceeding to the dock, as determined by the VTS data and Pilot's experience. Within the model's rules of operation, once the minimum anchorage time has expired, the vessel may proceed to the terminal dock when the dock becomes available and the other channel transit rules are satisfied.

2.3.6 Anchorage Use – From Dock

As previously stated in Section 1.1.4 of this appendix, vessels do not typically go from a dock to an anchorage for the purpose of freeing up the dock for another vessel. Doing so may be advantageous to the terminal operator, but it is expensive for the vessel because it creates two separate vessels movements each requiring tugs and pilots. Nevertheless, the SNTS may be configured to enable anchorage use from a dock. If there is a vessel movement from dock to anchorage, once the vessel arrives at the destination anchorage, it must occupy the anchorage the configured minimum duration (the default value is four hours) before being permitted exit the

waterway. The default setting of the SNTS is to not allow anchorage use from a dock and was not used during model simulations.

2.3.7 Bunkering

Analysis of bunkering practices in the waterway using vessel movement data provided by the Sabine Pilots and the US Coast Guard VTS for 2018 and 2019 reveals that vessels receive bunkering at anchorage and some terminals. Tow vessels categorized as providing bunker in VTS records were correlated with deep draft vessels at the same location at the same time as recorded in the Sabine Pilots vessel movement data to identify which vessels were receiving bunkering. Over the two-year span, 1,624 vessels were bunkered for an average duration of 7.3 hours. All vessels visiting an anchorage are assumed to bunker at the anchorage and must stay at anchorage a minimum amount of time to facilitate bunkering. Vessels visiting multiple docks where one dock does not have commodity transfer are assumed to bunker while at dock. These assumptions have been verified by the Sabine Pilots (Appendix C) to represent the practices of vessel and terminal operators within the SNWW.

2.3.8 Wait Time Calculation

Whether at sea, dock, or anchorage, vessels are not permitted to initiate vessel movements within the channel unless the aforementioned conditions are met. If a vessel is ready to begin a transit but the transit conditions do not permit movement, wait time is accrued and tracked by the SNTS. Wait times are categorized as either weather related, or non-weather related. Wait times due to weather conditions are unavoidable and affect all vessels attempting movement within the waterway. Non-weather related wait times may be caused by a number of different factors within the waterway such as pilotage rules (e.g., daylight restrictions or vessel meeting requirements), waterway traffic conditions (e.g., waterway congestion, limited tug or pilot availability), or dock and anchorage availability.

2.3.9 Vessel Voyage Conclusion

A vessel voyage is considered completed when the vessel, after completing the appropriate amount of time at dock, and having turned and proceeded to exit the waterway, passes the channel entrance. Once the vessel voyage is completed, the vessel has exited the waterway and is no longer considered active within the system.

3 Description of Output Data

Output of the SNTS model is in data tables and simulation renderings that are viewable in ArcGIS ArcMap.

3.1 Simulation Output

Every model simulation exports a set of data tables used to describe and summarize the output. Tables are exported in both Esri file geodatabase and Excel formats. These tables are used to compare simulations. In addition, the Esri file geodatabase contains a time-enabled point feature class depicting the location of all vessels transiting the waterway at each timestep. Tables 9 and 10 describe the content of SNTS output tables and Figures 8 and 9 depict sample tabular model output in both the Esri file geodatabase and an Excel spreadsheet.

Table 9
SNTS Output

Table	Description
Model Parameters	A list of all parameters used for the simulation, including any channel modifications or model constraints.
Vessel Call List	The vessel call list used in the simulation, which also includes the dock visited, turning basin used, vessel transit duration, and any time spent waiting and at anchorage.
Timestep Summary	A list of every timestep in the simulation and the aggregate number of vessels in motion, at dock, at sea, or anchored. Also recorded is the number of pilots and tugs used at each timestep. Finally, any vessel occupying each dock is recorded.
Weather Delays	The modeled weather delays used in the simulation.
Dock Use	A list of when each vessel reserved a dock, arrived at the dock, and departed the dock.
Anchorage Use	A list of when a vessel reserved an anchorage for use and when the vessel departed the anchorage.
Vessel Meetings	A list of every vessel's potential passing of another vessel. Each vessel is identified as either in-transit or seeking transit. Included is where the meeting would take place in the waterway, the channel width at that location, each vessel's physical characteristics, whether the meeting is permitted, and if the vessel meeting is denied, the reason for denying the vessel meeting.
Vessel Movements Complete	A list of every vessel's completed voyage through the waterway. Included is the vessel's location and status at each timestep the vessel is active within the SNTS, including waiting times and the reason for the delay.
Vessel Movements	A list of every vessel that did not complete the voyage through the waterway before the end of the simulation period. Included is the vessel's location and status at each timestep the vessel is active within the waterway, including waiting times and the reason for the delay. These vessels have not yet exited the waterway at the end of the simulation.

Table 10
SNTS Output Table Data Dictionary

Table	Field	Description
AnchorageUse	Anchorage	Anchorage code.
	VesselTransitID	Unique ID for the vessel voyage.
	StartAnchorTimeStamp	When the vessel reserved the anchorage for use.
	StopAnchorTimeStep	When the vessel departed the anchorage .

DockUse	Dock	Dock code.
	VesselTransitID	Unique ID for the vessel voyage.
	ReserveDockTimeStamp	When the dock was reserved for use.
	ArriveDockTimeStamp	When the vessel arrived at dock.
	DepartDockTimeStamp	When the vessel departed the dock.

ModelParameters	Parameter	The name of the model parameter used in the model run.
	Value	The value assigned to the parameter.
	Description	A static description of the model parameter recorded.

SystemDelaysModeled	DelayType	The reason for the delay. All values are “Fog”. Earlier iterations had other delay types, but the distinctions were deemed irrelevant.
	DelayStart	Time stamp of the start of the delay.
	DelayEnd	Time stamp of the end of the delay.

TimestepSummary	TimeStamp	The date and time of the timestep.
	VesselsInSystem	The total number of vessels being tracked (in motion, at dock, at sea, or at anchorage) at the timestamp.
	VesselsInMotion	The total number of vessels in the waterway at are not at dock, anchorage, or sea at the timestamp.
	VesselsAtDock	The number of vessels at dock at the timestamp.
	VesselsAtSea	The number of vessels waiting at sea at the timestamp.
	VesselsAnchored	The number of vessels at anchorage at the timestamp.
	PilotsUsed	The number of pilots being used in the timestamp
	TugsUsed	The number of tugs being used in the timestamp
	TractorTugsUsed	The number of tractor tugs being used in the timestamp

	BME through XOMx	Each field is the code name for a dock. If a dock has been reserved for or occupied by a vessel, the vessel transit id is recorded for the timestamp. Unoccupied or unreserved timestamps have a value of 0.

VesselCallList<year>	VesselTransitID	Unique ID for the vessel voyage.
	VesselMovementID	Was intended for multi-dock vessel calls. Subsequently abandoned. All values are 1.
	VesselName	The name of the vessel.
	IMO	The IMO of the vessel.
	Cargo	The cargo carried by the vessel.
	VesselClass	The class of the vessel (vessel type).
	DWT	Vessel deadweight tonnage.
	LOA	Vessel length overall in feet.
	Beam	Vessel beam in feet.
	Draft	Vessel design draft in feet.
	DockCalls	Number of calls for the vessel transit. All values are 1. Unused.
	StartDateTime	The date and time of the vessel arriving at the channel entrance, ready to being transiting the waterway.
	Year	The year of the StartDateTime.
	Dock	The dock the vessel eventually occupies (could be any of Dock1-3).
	Dock1	Candidate dock the vessel could potentially occupy.
	Dock2	Candidate dock the vessel could potentially occupy.
	Dock3	Candidate dock the vessel could potentially occupy.
	Terminal	The terminal associated with docks 1-3.
	Tons	Tons of cargo carried by the vessel.
	DockDuration	The minimum amount of time the vessel must be at dock to facilitate commodity transfer.
	preDockDraft	The draft of the vessel prior to docking.
	postDockDraft	The draft of the vessel after docking.
	OnlyDaylight	Boolean value indicating that the vessel would be subject to daylight restrictions, if in place.
	IsMultiMove	Boolean value indicating that the vessel transit includes multiple dock visits. All values are 0. Abandoned.
	CurrentStatus	The status of the vessel at the current timestep
	CurrentMeasure	The route-footage location of the vessel at the current timestep

CurrentDraft	The draft of the vessel at the current timestep.
TimeStamp	The last recorded timestep for the vessel transit.
Completed	Boolean value to record if the vessel transit has already been completed. Completed vessels are not considered in timestep queries.
TurningDuration	The number of minutes required to turn the vessel. All values are 13.
RouteUsed	The route used for the vessel transit. Values are PA-NR (Port Arthur – Neches River) or TB (Taylors Bayou).
HeadInOut	Value indicating whether the vessel docks “Head In” (turning after docking) or “Head Out” (turn before docking).
VesselSpeed	The speed of the vessel. Originally designed to allow vessel-specific speeds. All values are 7. Abandoned and unused.
TurningBasinName	Name of the turning basin used by the vessel.
TurningBasinMeasure	The route-footage location of the turning basin used by the vessel.
PilotsUsed	The number of pilots used to navigate the vessel based on vessel size.
DockMeasure	The route-footage location of the dock used by the vessel.
Dock1Measure	The route-footage location of the candidate dock the vessel could occupy.
Dock2Measure	The route-footage location of the candidate dock the vessel could occupy.
Dock3Measure	The route-footage location of the candidate dock the vessel could occupy.
TurningBasin1	Name of the candidate turning basin the vessel could use.
TurningBasin2	Name of the candidate turning basin the vessel could use.
TurningBasin3	Name of the candidate turning basin the vessel could use.
TurningBasin1Measure	The route-footage location of the candidate turning basin the vessel could use.
TurningBasin2Measure	The route-footage location of the candidate turning basin the vessel could use.
TurningBasin3Measure	The route-footage location of the candidate turning basin the vessel could use.
ImportExport	Whether the vessel is importing or exporting cargo.
SeaWaitTime	The number of minutes a vessel waits at sea prior to being able to enter the waterway.
TurnTime	Timekeeping value to record the number of minutes spent turning across timesteps.
DockTime	Timekeeping value to record the number of minutes at dock across timesteps.
DockWaitTime	The number of minutes the vessel spends at dock beyond those required to accomplish commodity transfer.

	UndockTime	Timekeeping value to record the number of minutes required to undock and no longer need tug assistance.
	AnchorageTime	The number of minutes the vessel spends at anchorage.
	WeatherTime	The number of minutes the vessel spends in a weather delay.
	WaitReason	The last reason for a delay in the vessel transiting the waterway.
	CurrentPilotsUsed	The number of pilots used by the vessel in the current timestep.
	CurrentTotalTugsUsed	The number of tugs used by the vessel in the current timestep.
	CurrentTractorTugsUsed	The number of tractor tugs used by the vessel in the current timestep.
	DestinationMeasure	The route-footage location of vessel destination .
	NextDestinationMeasure	The route-footage location of the next vessel destination.
	NextStatus	The next status anticipated for the vessel transit.
	HasDocked	Boolean value to record if the vessel has already docked.

VesselMeetings	TimeStamp	Timestep value in the model run.
	VesselTransitID	Vessel transit id of the current vessel being considered.
	ActiveVesselTransitID	The vessel transit id of the active, approaching vessel to be encountered by the current vessel.
	Route	The route of the current vessel transiting the waterway.
	MeetingMeasure	The route-footage location at which the two vessels would theoretically meet.
	ChannelWidth	The width of the channel at the Meeting Measure.
	AllowedToMeet	Boolean value to determine if the vessels would be allowed to meet at the meeting measure.
	vDWT	Current vessel deadweight tonnage.
	vBeam	Current vessel beam in feet.
	vDraft	Current vessel draft in feet.
	aDWT	Approaching vessel deadweight tonnage.
	aBeam	Approaching vessel beam in feet.
	aDraft	Approaching vessel draft in feet.
	DenyReason	If the vessels are not permitted to meet, this is the reason for denying the meeting of vessels.

VesselMovementsComplete	VesselID	Abandoned and unused.
	VesselTransitID	Unique ID for the vessel voyage.
	TimeStamp	Timestamp value in the vessel's transit.

	Status	The vessel status at the timestamp
	DistanceMeasure	The route-footage location on the route at the timestamp
	RouteUsed	The route used by the vessel
	TurnTime	The number of minutes used in the timestamp used to accomplish the turn.
	DockTime	The number of minutes accrued at dock during commodity transfer. Used for timekeeping.
	SeaWaitTime	The number of minutes the vessel has waited at sea so far at the current timestamp prior to being given access to the waterway.
	Draft	The draft of the vessel at the timestamp.
	DockWaitTime	The number of minutes the vessel has waited at dock so far at the current timestamp prior to being given access to the waterway.
	IsDaylight	Boolean value indicating that the current timestamp is during daylight hours.
	VesselMovementID	The unique dock call for multi-dock vessel voyages. Abandoned and unused. All values are 1.
	DestinationMeasure	The route-footage location of the vessel's destination, whether a dock, turning basin, anchorage, or sea.
	NextDestinationMeasure	The route-footage location of the vessel's next destination, whether a dock, turning basin, anchorage, or sea.
	NextStatus	The next status to be anticipated by the vessel once it has reached the destination measure.
	WaitReason	If unable to move, the reason the vessel is unable to transit the waterway at the current timestamp.
	PilotsUsed	The number of pilots used by the vessel at the current timestamp.
	TotalTugsUsed	The total number of tugs used by the vessel at the current timestamp.
	TractorTugsUsed	The number of tractor tugs used by the vessel at the current timestamp.
	UndockTime	The number of minutes since undocking. Used to track tug usage after leaving dock.
	VesselClass	The type/class of vessel.
	AnchorageTime	The number of minutes the vessel spent at anchorage.

VesselMovements	VesselID	Abandoned and unused.
	VesselTransitID	Unique ID for the vessel voyage.
	TimeStamp	Timestamp value in the vessel's transit.
	Status	The vessel status at the timestamp
	DistanceMeasure	The route-footage location on the route at the timestamp
	RouteUsed	The route used by the vessel

	TurnTime	The number of minutes used in the timestamp used to accomplish the turn.
	DockTime	The number of minutes accrued at dock during commodity transfer. Used for timekeeping.
	SeaWaitTime	The number of minutes the vessel has waited at sea so far at the current timestamp prior to being given access to the waterway.
	Draft	The draft of the vessel at the timestamp.
	DockWaitTime	The number of minutes the vessel has waited at dock so far at the current timestamp prior to being given access to the waterway.
	IsDaylight	Boolean value indicating that the current timestamp is during daylight hours.
	VesselMovementID	The unique dock call for multi-dock vessel voyages. Abandoned and unused. All values are 1.
	DestinationMeasure	The route-footage location of the vessel's destination, whether a dock, turning basin, anchorage, or sea.
	NextDestinationMeasure	The route-footage location of the vessel's next destination, whether a dock, turning basin, anchorage, or sea.
	NextStatus	The next status to be anticipated by the vessel once it has reached the destination measure.
	WaitReason	If unable to move, the reason the vessel is unable to transit the waterway at the current timestamp.
	PilotsUsed	The number of pilots used by the vessel at the current timestamp.
	TotalTugsUsed	The total number of tugs used by the vessel at the current timestamp.
	TractorTugsUsed	The number of tractor tugs used by the vessel at the current timestamp.
	UndockTime	The number of minutes since undocking. Used to track tug usage after leaving dock.
	VesselClass	The type/class of vessel.
	AnchorageTime	The number of minutes the vessel spent at anchorage.

VesselsMet	TimeStamp	Timestep value in the model run.
	VesselTransitID	Vessel transit id of the current vessel being considered.
	ActiveVesselTransitID	The vessel transit id of the active, approaching vessel to be encountered by the current vessel.
	Route	The route of the current vessel transiting the waterway.
	MeetingMeasure	The route-footage location at which the two vessels would theoretically meet.
	ChannelWidth	The width of the channel at the Meeting Measure.
	AllowedToMeet	Boolean value to determine if the vessels would be allowed to meet at the meeting measure. Value will be 1 for all records since this is a record of vessels that met.

	vDWT	Current vessel deadweight tonnage.
	vBeam	Current vessel beam in feet.
	vDraft	Current vessel draft in feet.
	aDWT	Approaching vessel deadweight tonnage.
	aBeam	Approaching vessel beam in feet.
	aDraft	Approaching vessel draft in feet.
	DenyReason	None for all records.

Figure 8
SNTS Output Timestep Summary Table in ArcGIS

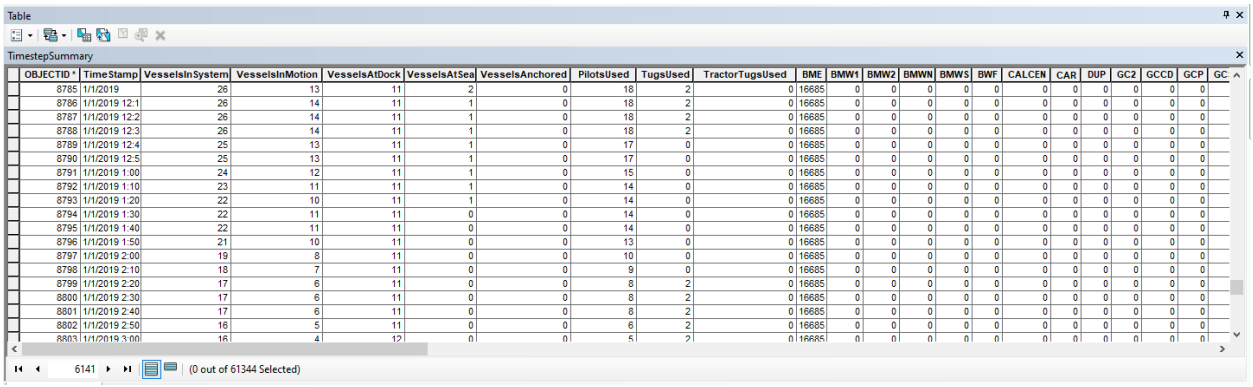
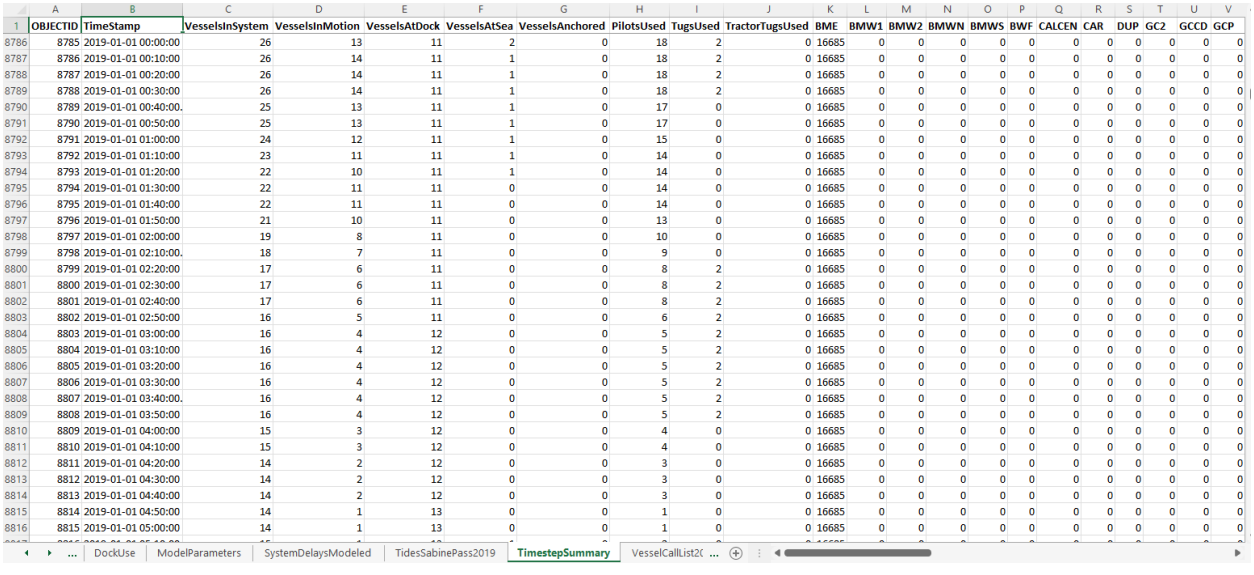


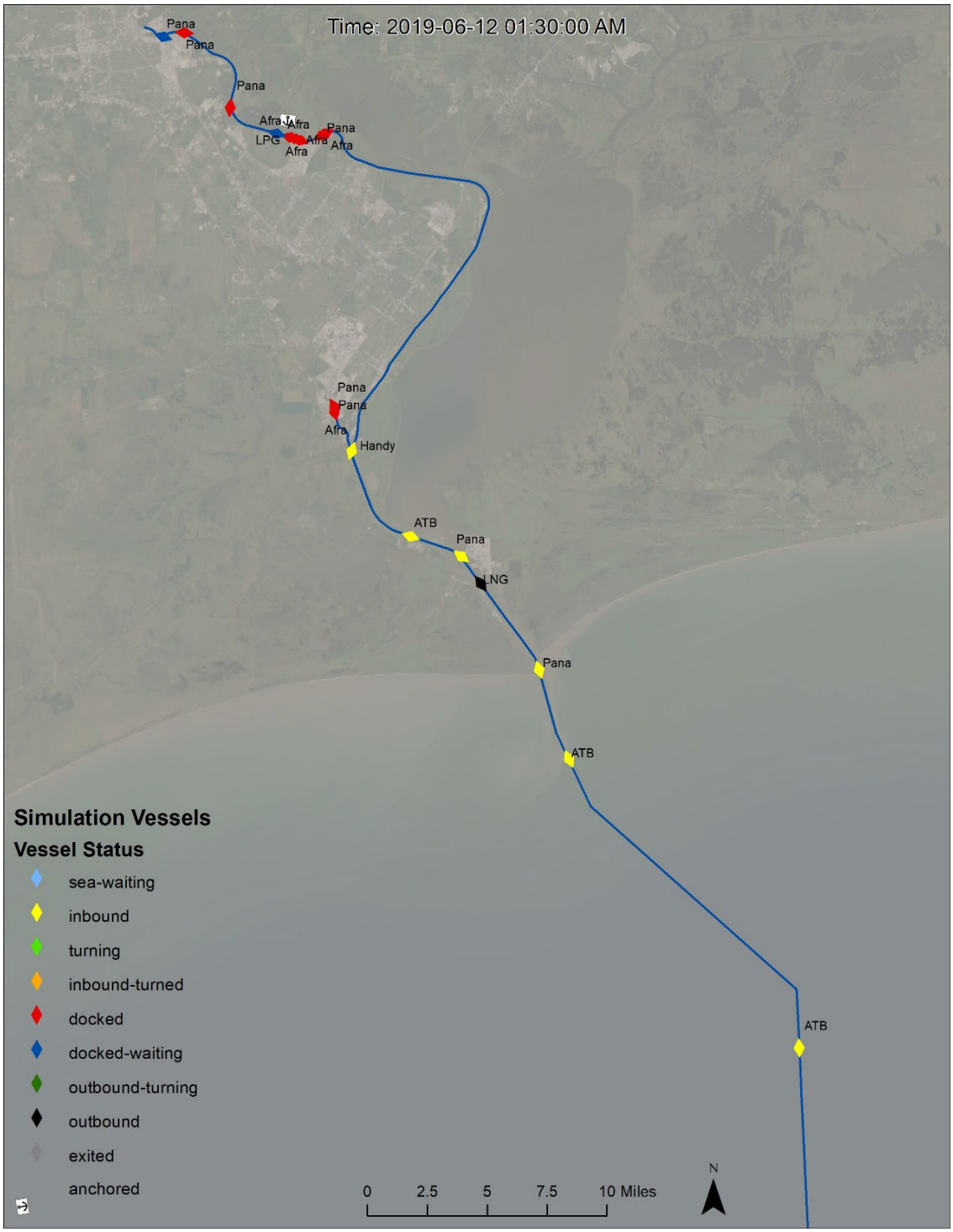
Figure 9
SNTS Output Timestep Summary Table in Excel



3.2 Simulation Rendering

Output from SNTS simulations is visualized in time-series animations in ArcGIS. The movement of each vessel through the waterway can be viewed in each ten-minute timestep. Each vessel is labeled by vessel class and symbolized by the vessel status (i.e., inbound, docked, anchored, outbound, etc.). Simulation animation rendering is helpful for visually validating vessel motions and vessel interactions. Chosen as an example, Figure 10 portrays the simulated state of the waterway on June 12 at 1:20 AM. Note the six yellow inbound vessels, ten docked vessels, three blue vessels that are docked, but waiting to exit, and one vessel at anchorage. Additional vessels are at sea waiting at the channel entrance, which is not depicted in Figure 10 because doing so would require the map to be at too small of a scale to meaningfully portray other details of the channel. A brief example of a simulation rendering may be viewed at https://www.youtube.com/watch?v=7wEkUDsPEgE.

Figure 10
Simulated State of Waterway on June 12 at 1:20 AM



3.3 Simulation Post-processing

Post-processing of SNTS traffic model results to calculate delay costs takes place entirely within an Excel workbook. Output tables from the SNTS model are loaded into an Excel Model Summary workbook designed to process output from multiple SNTS simulations using different parameters, thereby enabling the comparison of simulation outputs. The Model Summary workbook uses the indirect referencing technique, which allows the SNTS output data to remain in its original form, with its data mirrored in the Model Summary workbook.

Data for each vessel in the Vessel Call List SNTS output file are assembled in the Model Summary workbook, which includes (but it not limited to) the following:

- Vessel Name & Class
- DWT, LOA, Design Draft
- Cargo type, cargo tonnage, cargo movement direction (export vs import)
- Turning basin used
- Terminal called and terminal dock used
- Dock time duration
- Sea Wait Time
- Dock Wait Time
- Weather Delay Time

Deep Draft Vessel operating costs associated Sea Wait Time, Weather Delay Time, and Dock Wait Time are calculated for each vessel using an hourly cost lookup table segmented by vessel DWT. Note that USACE Vessel Operating Costs are proprietary and are not currently available. When and if these costs become available, they will be applied by vessel type (e.g. tanker, LNG, LPG, etc.) and size (DWT).

SNTS model parameters (included as a worksheet in the SNTS output file) used for the simulation, including any channel modifications or model constraints are also loaded into the Model Summary workbook. Loaded parameters include:

- Model Run Date
- Simulated Year (2025, 2030, 2035, 2040, 2045, 2050)
- 24-Hour Operation or Daylight Operation
- Sabine Pass Channel Widening (0, 500, 600, or 700 feet),
- Port Arthur Canal Widening (0, 500, 600, or 700 feet),
- Sabine-Neches Canal North Widening (0, 500, 600, or 700 feet),
- Sabine-Neches Canal South Widening (0, 500, 600, or 700 feet),
- Neches River Channel Widening (0, 500, 600, or 700 feet),

The parameters combine to form a Model Run category, which accompanies data for each vessel in the Model Summary workbook. The Model Run category is used as the main segmentation factor in Model Summary workbook pivot tables for the following metrics:

- Transits with Zero Sea Wait Time

- Transits with Zero Dock Wait Time
- Transits with Zero Anchorage Time
- Sea Wait Hours Sum
- Dock Wait Hours Sum
- Excess Anchorage Hours Sum
- Total Wait Time
- Sea Wait Hours Max
- Dock Wait Hours Max
- Excess Anchorage Hours Max
- Docked Hours Sum
- Docked Hours Max
- Sea Wait Cost Sum
- Dock Wait Cost Sum
- Wait Cost Total

In addition to overall summary results, the Model Summary workbook also further segments results by vessel type and terminal. By using the Excel spreadsheet, model results and analytics can be exported into project reports.