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DELTA STEWARDSHIP COUNCIL

SHORE-BASED BALLAST WATER TREATMENT IN CALIFORNIA

TASK 11: IMPLEMENTATION TIMELINE

PREPARED FOR

DELTA STEWARDSHIP COUNCIL
SACRAMENTO, CALIFORNIA

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Revision History

Section	Rev	Description	Date	Approved
All	-	Released as final.	20 Feb 2018	KJR

References

1. *Shore-Based Ballast Water Treatment in California, Task 13: Other Analysis and Findings,* Glosten, 20 September 2017.
2. *Shore-Based Ballast Water Treatment in California: Memorandum on Scale-up of Land-based and Barge-based Alternatives*, Glosten, 6 April 2017.
3. *Shore-Based Ballast Water Treatment in California, Task 7: Permitting and Legal Requirements,* Glosten, 20 September 2017.

Executive Summary

This report describes the timeline necessary to accomplish the known tasks required to develop a network of ballast water treatment barges (treatment barges). This implementation timeline begins with estimates of the time required to accomplish required research and development of the barge-based ballast water management technologies and continues through commissioning and full system implementation. It is expected that a phased-in implementation would be possible, progressing as the necessary infrastructure is completed and ships are retrofitted with the necessary transfer connections.

As can be seen in Figure 1, the overall timeline for full implementation is expected to be about nine years from the start of the research and development of the barge-based treatment technologies to completion of retrofitting of the ships. It is likely that shore-based treatment can begin to be phased in after six years, as treatment barges become available and ships have begun to be retrofitted with the necessary transfer connections.

The treatment barge network implementation timeline includes a schedule of known tasks for design, permitting, construction, and commissioning of the barge-based ballast water management system. This implementation timeline is dependent on the size of the barge network required, as determined in Task 13.

Separately, the shipboard modifications timeline has been developed for implementation of the modifications required to allow the arriving ships to utilize the barge-based ballast water management system. This timeline includes the schedule to accomplish design, permitting, and modifications on the ships, aligning with typical ship dry-docking schedules.

There are several areas of uncertainty in the timeline. The research and development of the barge-based treatment technologies could delay by up to two years, as shifting the technologies from land to barge is proven. Permitting delays could add 18 months to implementation, as analysis and field studies inform permit requirements. In addition, there is uncertainty on the mechanism to require marine vessels to arrive with compliant ballast transfer stations, potentially resulting in delays to implementation.

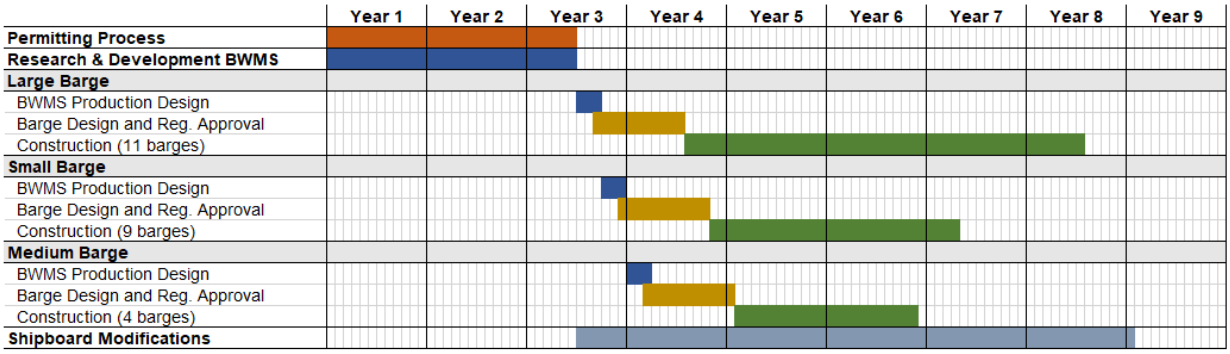

Figure 1 Overall implementation timeline

Introduction

This report is part of an overall coordinated study evaluating the feasibility of using shore-based mobile or permanent ballast water treatment facilities to meet California's Interim Ballast Water Discharge Performance Standards (CA Interim Standards). This report is presented to the Delta Stewardship Council to meet the objectives of Task 11 – Implementation timeline. Description of the overall study can be found in Appendix A, along with definitions for terms used in this study.

This report (Task 11) assesses the timeline for implementation of the barge network described in Task 13, including permitting, design and construction of the required number of treatment barges, as well as the time required for retrofitting of oceangoing vessels.

Barge Network Implementation Timeline

Research and Development of the Treatment Technologies

The first major stage in the development of a barge-based ballast water management system is the research and development of the barge-based treatment technologies. This has been estimated to take a total of 33 months. This includes the following tasks:

1. Ballast water management technology selection/concept design – 6 months.
2. Stakeholder review and comment – 3 months.
3. Pre-prototype testing effort – 6 months.
4. Ballast water treatment system prototype design – 6 months.
5. Ballast water treatment system prototype fabrication/testing/demonstration – 6 months.
6. Ballast water treatment system efficacy and effluent regulatory approval for compliance with California's requirements – 3 months.
7. Ballast water treatment system production design – 3 months.

   Total timeline – minimum – 33 months.

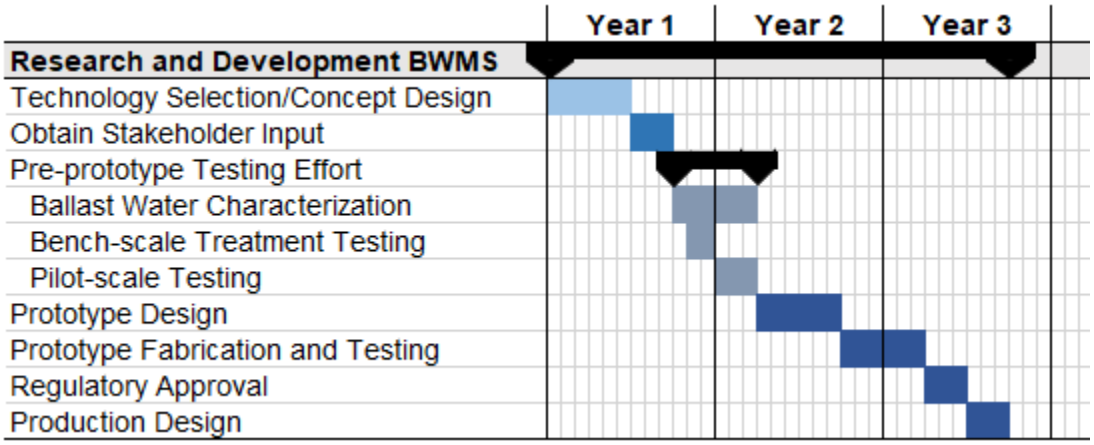

Figure 2 Research and development timeline

This is an aggressive timeline and there is the possibility for these tasks to extend an additional 18-24 months should unforeseen hurdles be encountered during the research and development stage.

There is limited available literature on proposed technologies for the treatment of ballast water. The pre-prototype testing will be done to determine if these technologies can meet the CA Interim Standards. The pre-prototype testing effort is anticipated to last approximately 6 months, and may include the following activities:

- Ballast water characterization testing – 6 months, ongoing throughout the testing phase. Characterization testing may include organism counts, organic carbon content, presence of oils and metals, and salinity and pH measurements.
- Bench-scale coagulation, membrane rejection/fouling/UV disinfection using a variety of ballast water samples – 2 months, minimum.

- Pilot-scale testing – 3 months, minimum.
  Pilot-scale testing may include challenge tests and energy audits.

Once the pilot-scale testing has been satisfactorily completed, production design of the actual BWMS for each of the different size barges will begin. A separate BWMS production design will be required for each of the three sizes of barges being built. It has been assumed that these separate designs will be accomplished by the same design team in a linear sequence. The BWMS production design for the large barge is assumed to occur first to support the optimal production schedule, followed by the small barge and then the medium barge.

Research and development of the treatment technology is the first and most important stage in the barge network development. Actual barge design cannot commence prior to completion of this research and development process. Final barge design will be dependent on completion of the BWMS production design.

Barge Network Design

The barge network design stage will consist of the following primary tasks:

- Design of each size of barge.
- Development of barge network construction specifications.
- Regulatory review and approval of each barge design.

There are three different barge sizes envisioned for the barge network that will require similar but separate barge design efforts for successful implementation. These barge design tasks may occur simultaneously, but will require substantial completion of their respective BWMS production design prior to completion of the actual barge design.

It has been assumed that nine months will be required to complete each barge size. This is based on expert opinion and the typical design time required for vessels of this size and complexity, noting that the design time assumes that the previous treatment technology development tasks have been completed. A minimum overlap of four months will be required with the BWMS production design effort to ensure proper integration of the BWMS into the barge designs. These time estimates have a high degree of confidence, but could vary by up to three months.

It has been assumed that regulatory review and approval of each barge design will be accomplished in the two months following completion and submittal of the design. This time estimate has a moderate degree of confidence and could vary by up to two months.

Barge Network Construction

The barge network construction stage will consist of the following primary tasks:

- Advertisement/bid for barge construction.
- Contract review, negotiation, and award.
- Barge construction.
- Barge delivery.
- Barge commissioning.

The barge network as described in Task 13 consists of the following sizes and quantities of barges:

- Large barge – 11 each.

- Medium barge – 4 each.
- Small barge – 9 each.

In an effort to strike a balance between cost and schedule, it has been assumed all barges of a given size will be constructed by a single builder. This will allow a builder to "tool up" and optimize their fabrication methods for a series of identical barges. With the three different barge designs, this will require the administration and supervision of three different contracts with potentially three separate builders simultaneously.

The large barges will take longer to build and as there are more of them, present the longest schedule for completion.

Large barge construction timeline:

- Advertise/bid for barge construction – 2 months.
- Contract review, negotiation and award – 2 months.
- Barge construction – 12 months for first barge, 9 months for subsequent barges.
- Barge delivery – 1 month for each barge.
- Barge commissioning – 1 month for each barge.
- Overlap in construction – builder able to deliver a barge every 3 months.

Total estimated time for construction and commissioning of the 11 large barges is about 45 months, as illustrated in Figure 3. This is the largest overall timeline of the different size barges and is why the BWMS production design effort needs to occur before the other two barge sizes. There is a moderate degree of confidence in this time estimate.

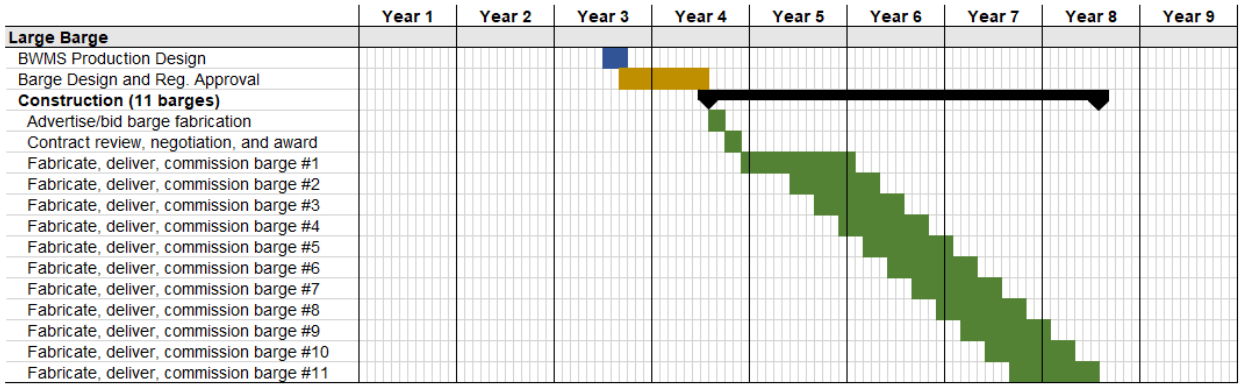

Figure 3 Large barge construction timeline

Medium barge construction timeline:

- Advertisement/bid for barge construction – 2 months.
- Contract review, negotiation and award – 2 months.
- Barge construction – 10 months for first barge, 8 months for subsequent barges.
- Barge delivery – 1 month for each barge.
- Barge commissioning – 1 month for each barge.
- Overlap in construction – builder able to deliver a barge every 2 months.

Total estimated time for construction and commissioning of the four medium barges is about 22 months, as illustrated in Figure 4. This is the shortest overall timeline of the different size barges. There is a moderate degree of confidence in this time estimate.

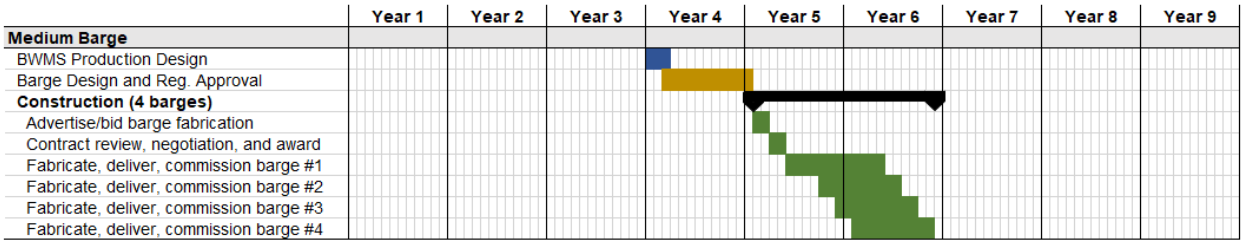

Figure 4 Medium barge construction timeline

Small barge construction timeline:

- Advertise/bid for barge construction – 2 months.
- Contract review, negotiation and award – 2 months.
- Barge construction – 8 months for first barge, 6 months for subsequent barges.
- Barge delivery – 1 month for each barge.
- Barge commissioning – 1 month for each barge.
- Overlap in construction – builder able to deliver a barge every 2 months.

Total estimated time for construction and commissioning of the 9 small barges is about 28 months, as illustrated in Figure 5. There is a moderate degree of confidence in this time estimate.

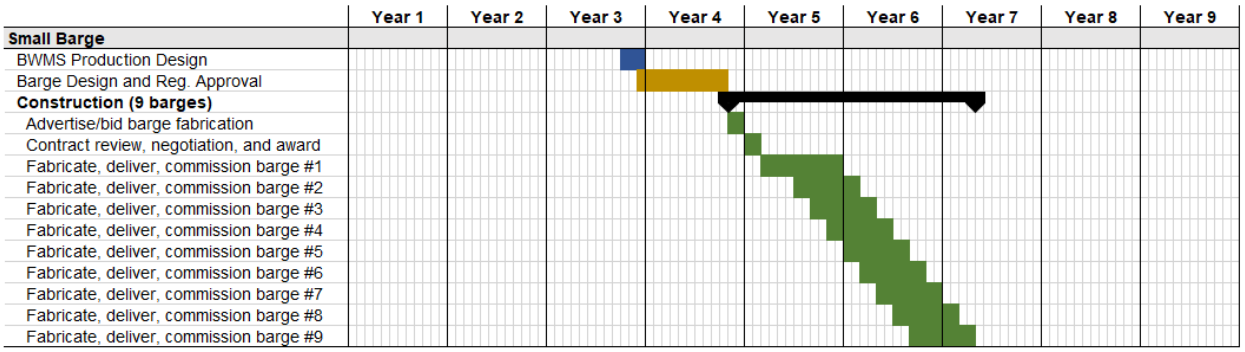

Figure 5 Small barge construction timeline

Commissioning of each barge will include complete operational testing and demonstration of all barge-based systems, including the BWMS. It is anticipated that performance testing of the BWMS to prove system capability would be completed. It is anticipated that such BWMS testing would include connecting to, receiving and processing ballast water from available ships. Effluent would be analyzed to insure compliance with the CA Interim Standards. Upon successful completion of the performance testing, each barge would receive a certificate allowing the barge to perform BWMS operations.

There are alternate strategies that could be utilized to shorten this timeline, but these generally involve increasing the parallel construction. This will increase the construction costs, require increased construction supervision, and increase the probability of differences in the barges for the operating crews.

Shipboard Modifications

There will be modifications required to each of the ships calling California ports to allow them to utilize a barge-based ballast water management system network. The timeline for these modifications includes the following tasks:

- Design time – 4 months.
- Stakeholder review and comment – 3 months.
- Regulatory approval time – 2 months.
- Implementation time – a 5-year window was assumed for the modifications to allow the ship owners to coordinate the necessary shipboard modifications within their normal ship maintenance and inspection period.

There is a moderate degree of confidence in the design time and regulatory approval time estimates. However, because of the duration of the five-year window, there is a high degree of confidence in this overall time estimate. See Figure 6.

There are, however, some concerns regarding the mechanism to require marine vessels to make these modifications, discussed in more detail in Task 7. The most significant of these concerns is that California may be preempted from requiring these shipboard transfer stations, and may instead need to rely on enforcement of the CA Interim Standards. The resulting ambiguity could result in delays.

The timeline assumes that the design of the shipboard modifications would begin upon both resolution of the permitting process and completion of the BWMS research and development efforts.

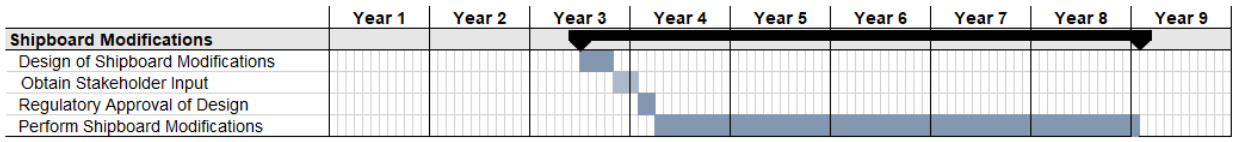

Figure 6 Shipboard modifications timeline

Permitting Process

The barge discharges will need to be permitted as per the requirements of the EPA National Pollutant Discharge Elimination System (NPDES). More information on the permitting process can be found in the Task 7 report, Reference 3. This is a public process that will require the following timeline on a per district basis:

- Permit discharge studies – 6 months.
- Permit drafting – 12 months.
- Permit issue, including public hearings – 12 months.

The total process should also include a contingency, allowing 3.5 years in total. In particular, freshwater locations will require additional time to understand and determine impact of saltwater marine discharges. This process will require careful sequencing with the barge design and approval process, as the barge outfall methods may be impacted.

Appendix A Study Overview and Definitions

Study Overview

Marine vessels routinely uptake ambient sea or harbor water as ballast, transit to another port, and then discharge that ballast water. Unfortunately, the resulting ballast water discharges have been linked to the introduction of aquatic invasive species and harmful pathogens. In an effort to reduce or possibly eliminate further introductions, marine vessels are being required to manage ballast water discharges by a myriad of international, federal, and regional guidelines and rules. Vessels discharging in California will be required to meet an interim standard that is more stringent than international and US federal standards.

In response, there has been significant development work and commercial installations of ballast water management systems (BWMS) onboard marine vessels themselves. However, there is a lack of data to determine if shipboard BWMS are capable of meeting CA Interim Standards. Therefore, shore-based ballast water reception and treatment is under consideration as an approach to meet the CA Interim Standards.

This study evaluates the feasibility of shore-based ballast water reception and treatment in 13 separate tasks, beginning with a review of shore-based treatment research, followed by a series of detailed analyses, including: permitting and legal requirements, detailed cost estimates, timeline to implementation, and market implications.

Tasks Overview

Tasks 6 through 13 are submitted together to discuss the practical implementation of shore-based ballast water reception and treatment throughout California state waters, accomplished by a "network" of six (6) independently operating fleets of mobile treatment barges (see Table A-1).

During the course of this study, following completion of Tasks 2-5 and the comparative scale-up exercise described in Reference 2, this approach was deemed most technically, operationally, and financially feasible of the five approaches that were evaluated (i.e. new onsite treatment facility, new offsite treatment facility, existing wastewater treatment facility, shore-side mobile treatment, mobile marine vessel-based treatment).

Table A-1 Tasks 6 through 13

Task	Description
6	Assessment of construction related to outfalls for treated ballast water discharges, and provision for disposal of solids as needed.
7	Summarize pertinent permitting and legal requirements.
8	Comparative review of shipboard vs. barge-based ballast water management operations.
9	Assessment of current practices related to ballast water discharges in California.
10	Cost analysis.
11	Implementation timeline.
12	Market implications.
13	Other analysis and findings. Introduces the concept of a statewide network of mobile treatment barges for the provision of ballast water reception and treatment services across the state, and forms the basis for assessments and analyses in Tasks 6-12.

Definitions

ABS	American Bureau of Shipping
ANSI	American National Standards Institute
ASTM	An international standards organization.
ATB	Articulated Tug Barge
AWL	Height Above Waterline
AWWA	American Water Works Association
Ballast Water	Water taken on by a ship to maintain stability in transit.
Ballast Water Exchange	The process of exchanging a vessel's coastal ballast water with mid-ocean water to reduce concentration of non-native species in accordance with regulatory guidelines.
Ballast Water Management	The entire process of treatment and handling of a ship's ballast water to meet regulatory requirements and prevent spread of non-native species.
BMPF	Ballast Manifold Presentation Flange
Booster Pump	Pump, typically centrifugal, that adds additional pumping force to a line that is already being pumped.
BWDS	Ballast Water Discharge Standards
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWMS	Ballast Water Management System
BWTP	Ballast Water Treatment Plant
BWTB, BWT Barge	Ballast Water Treatment Barge
BWTS	Ballast Water Treatment System
Capture	Capture is the method by which ballast water is transferred onto or off a marine vessel.
CD	Chart Datum
CFU	Colony Forming Units
CMSA	California Marine Sanitation Agency
DAF	Dissolved Air Floatation
DIN	Deutches Institut für Normung (German Institute for Standardization)
Discharge	Discharge of ballast water is the method by which post-treatment ballast water is disposed of in compliance with applicable standards and regulations.
DOC	Dissolved Organic Carbon
DWT	Deadweight Tonnage
EPA	Environmental Protection Agency (US, unless otherwise noted)
Filtrate	Water that has been separated from any particulate matter (used to clean ballast water treatment filters).
GA	General Arrangement
GM	Metacentric height (a measure of a ship's stability).

gpm	Gallons per minute. Any measurements quoted in gallons of ballast water per minute will also be shown in MT of ballast water per hour, or MT/h.
HDPE	High-density Polyethylene
IMO	International Maritime Organization
ISO	International Organization for Standardization
JIS	Japanese Industrial Standards (organization)
L	Liter
Lift Station	Means of receiving a liquid, typically from a drain or low-pressure piping, and 'lifting' it with pump(s) to a different location such as a remote tank.
Lightering	Cargo transfer between vessels, commonly practiced to reduce a vessel's draft before entering port.
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MARPOL	International Convention for the Prevention of Pollution from Ships
MF	Microfiltration
mg	Milligram
MG	Millions of gallons. Any measurements quoted in MG of ballast water will also be shown in MT of ballast water.
MGD	Millions of Gallons/Day
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MPA	Megapascal (unit of pressure)
MSL	Mean Sea Level
MT	Metric tons. One cubic meter of seawater is roughly equivalent to 1.025 MT, but this value varies depending on temperature and salinity of the water. In this report, conversions between volume and weight of seawater are merely approximate and assume 1 m3 of seawater has a mass of roughly 1 MT, for convenience.
Navy Mole	A man-made peninsula in the Port of Long Beach that flanks entrance to the middle and inner harbor
NBIC	National Ballast Information Clearinghouse
NOM	Natural Organic Matter
Non-native Species	Species that are not indigenous to a particular region. Non-native species can be introduced to marine ecosystems through a ship's ballast water. "Invasive" species are non-native species with the potential to cause harm to the environment or human health.
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance (cost)
OCIMF	Oil Companies International Marine Forum
POTW	Publicly Owned [Wastewater] Treatment Works
PSU	Practical salinity units.
Residuals	Particulate matter collected from cleaning ballast water treatment filters.
ROM	Rough Order of Magnitude (cost)

Ro-ro	Roll-on/roll-off (vessels designed to carry wheeled cargo such as car, trucks, trailers, and equipment)
RWCF	Regional Wastewater Control Facility (e.g. City of Stockton, CA)
Shipboard Ballast Water Treatment	Ballast water management approaches that do not require support from shore-based infrastructure and are conducted entirely by a vessel's crew.
Shore-Based Ballast Water Management	Ballast water management approaches that require support from shore-based infrastructure in order to meet ballast water management requirements. Such infrastructure may include: means of transferring ballast water to a land-based or another marine vessel facility for storage and/or processing, deployment of shore-based equipment and personnel for onboard treatment approaches, etc.
Slurry	Mixture of filtrate and filter residuals resulting from cleaning ballast water treatment filters.
Slurry Handling	Slurry handling includes activities related to the storage, treatment, and discharge of filtrate and residuals collected from cleaning ballast water treatment filters.
SOLAS	International Convention for Safety of Life at Sea
Storage	Storage of ballast water includes provision of space and containment for ballast water, either pre-or post-treatment.
STS	Ship-to-Ship. Transfer from one marine vessel to another.
TDS	Total Dissolved Solids
TEU	Twenty-foot Equivalent Unit
TOC	Total Organic Carbon
Transfer	Ballast water transfer considers the logistics and equipment required to capture the ballast water from the marine vessel and transport to a reception and treatment facility.
Transport	Transport is the method by which ballast water is moved post-capture from marine vessels to remote, non-mobile reception and treatment facilities – either land-based or otherwise.
Treatment	Treatment includes the various methods to process ballast water such that it is suitable for discharge in compliance with applicable standards and regulations.
Treatment Approach	A general method for implementing ballast water treatment. Treatment approaches may include mobile systems, land-based facilities, shipboard systems, etc.
Treatment Technology	Specific techniques for removal or inactivation of organisms in ballast water (e.g., UV disinfection, filtration, ozonation, etc.)
TRO	Total Residual Oxidant
TSS	Total Suspended Solids
UF	Ultrafiltration
UKC	Underkeel Clearance
UL	A global independent safety consulting and certification company (formerly Underwriters Laboratories).
USCG	United States Coast Guard
UV	Ultraviolet Light
UVT	UV Transmittance
VLCC	Very Large Crude Carrier
WWTF	Waste Water Treatment Facility

WWTP	Waste Water Treatment Plant