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Boat Pump-Out BMP Expert Panel Report

Chesapeake Bay Program
Science. Restoration. Partnership.

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Prepared for

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EXECUTIVE SUMMARY

In February, 2015, the Chesapeake Bay Program's (CBP) Wastewater Treatment Workgroup (WWTWG) was asked to consider Boat Pump-Out Facilities within No Discharge Zones (NDZ) as a BMP eligible for nutrient reduction credit within the Phase 6.0 Watershed Model. The Chesapeake Bay Boat Pump Out BMP Expert Review Panel (the Panel) was convened by the CBP Office in February 2016 to develop a report that evaluates, defines and configures the proposed Boat Pump-Out Facility BMP for nutrient reduction credit within the Chesapeake Bay Program's Phase 6.0 Watershed Model.

Boat discharge load is new to the Bay water quality model - there is no existing background accounted for in the model. Therefore, the Panel focused on estimating historical loads from jurisdictions with Bay tidal waters, developing time series nutrient load estimates for Virginia and Maryland (note that DC and Delaware also have some tidal waters but were not actively represented on the Panel). Both Maryland and Virginia have boat pump out laws requiring marinas with 50 or more slips to have pump-out facilities.

In addition to documenting historical and future loads, the CBP also wants to be able to acknowledge and incentivize good programs that are in place to reduce nutrient loads from boat discharges. Accordingly, the Panel recommends that the development of a boat pump out program be approved as a programmatic BMP. Although each individual pump-out facility installation would not be credited, the programmatic BMP could be part of a jurisdictions' Phase 3 (2018-2025) watershed implementation plans (WIPs) and included as a management target if desired by the jurisdiction.

The methodology described and applied in the Maryland and Virginia estimates provides current baseline tracking, which could also be replicated by other interested states or local jurisdictions. Tracking of future loads and load reductions could use similar methodologies, although metering, other load estimation procedure, an additional future marina survey, etc. may be warranted.

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
BMP	Best Management Practices
CBP	Chesapeake Bay Program
CMI	Clean Marina Initiative
CTO	Certificate to Operate
CVA	Clean Vessel Act
CWA	Clean Water Act
CZM	Coastal Zone Management
DNR	Maryland Department of Natural Resources
HRSD	Hampton Roads Sanitation District
MARPOL	International Convention for the Prevention of Pollution from Ships
MSD	Marine Sanitation Device
NDZ	No Discharge Zones
The Panel	The Boat Pump Out BMP Expert Review Panel
TN	Total Nitrogen
TP	Total Phosphorus
USEPA	United States Environmental Protection Agency
VDH	Virginia Department of Health
WIP	Watershed Implementation Plan
WWTWG	Wastewater Treatment Workgroup

1.0 INTRODUCTION

In February, 2015, the Chesapeake Bay Program's (CBP) Wastewater Treatment Workgroup (WWTWG) was asked to consider Boat Pump-Out Facilities within No Discharge Zones (NDZ) as a BMP eligible for nutrient reduction credit within the Phase 6.0 Watershed Model. The proposal recommended the reductions be based upon direct monitoring of nitrogen and phosphorus removal at the pump-out facilities from Type I and II Marine Sanitation Devices (MSD) (treat and release systems), which would be reported to CBP by the jurisdictions on an annual basis. While the WWTWG was comfortable with the proposed approach of providing credit based upon directly monitored reductions, there were several outstanding regulatory and modeling issues that workgroup members felt required further evaluation. The workgroup also requested that the scope of evaluation should also be expanded to cover all pump-outs, not just within NDZ.

The Chesapeake Bay Boat Pump Out BMP Expert Review Panel (the Panel) was convened by the CBP Office in February 2016 and coordinated via conference call periodically between March 2016 and March 2018. The main charge for the Panel was to develop a report that evaluates, defines and configures the proposed Boat Pump-Out Facility BMP for nutrient reduction credit within the Chesapeake Bay Program's Phase 6.0 Watershed Model. The Panel would evaluate the policy and regulatory implications of providing credit for the pump-out practice, and provide a recommended methodology for reporting and modeling the reductions.

In its charge by the CBP, the Panel was specifically requested to:

1. Identify any regulatory constraints associated with providing nutrient reduction credit for Boat Pump-Out from Type I and II MSD within the Chesapeake Bay watershed, and provide a recommendation as to whether or not to credit the practice in the Phase 6.0 Watershed Model given the identified constraints.

If following completion of the first charge, the recommendation is to provide nutrient reduction credit in the Phase 6.0 Watershed Model, the Panel was further charged with the following tasks:

2. Define the baseline load against which the nutrient reductions from Boat Pump-Out Facilities would be credited. If a new source load must be established, the Panel should define the new nutrient loading source for the model and provide a methodology for establishing the baseline/historical loads for this new source.
3. Develop the procedures for tracking, reporting and verifying the recommended credits.
4. Document any data needs for supporting future revisions to the recommended reduction credits.
5. Critically analyze any unintended consequences associated with the methodology and any potential for double or over-counting of nutrient reduction credit.

Subsequent discussion among the Panel with CBP staff clarified that the Panel's findings and recommendations should reflect a weight of evidence/best professional judgement approach. Boat discharge load is new to the Bay water quality model - there is no existing background accounted for in the model. Importantly, if the CBP is interested in quantifying (and thus incentivizing) load reductions from this source, the baseline load needs to be quantified. Therefore, the Panel focused on the fundamentally important question of estimating historical loads from the most significant jurisdictions with sufficient data. The Chesapeake Bay model record spans from 1985 through 2015 which covers periods where there was virtually no control to more recently implemented efforts in making reductions in boat discharges. Additionally, boating participation is expected to fluctuate from year to year depending primarily on the economy.

In addition to a load change over time, there will be a definite seasonal influence. In the Bay water quality model, point source discharges are typically annual, but can be input as a daily time step. Furthermore, the model can factor in travel times from various areas to the Bay tidal waters. Accordingly, the spatial distribution of the loads is important. The Panel focused on represented jurisdictions with Bay tidal waters – Virginia and Maryland (note that DC and Delaware also have some tidal waters but were not actively represented on the Panel). Both Maryland and Virginia have boat pump out laws requiring marinas with 50 or more slips to have pump-out facilities.

Upon further review of the original charge, the Panel concluded that it would be inappropriate to limit the analysis and potential BMP to to Type 1 and 2 MSDs in NDZs, since Type 1 and Type 2 MSDs typically discharge directly and some may not include storage sufficient to use pump out facilities. Additionally, all three MSDs – Type 1, 2 and 3 – are illegal to discharge in NDZs (note that any discharge of untreated sewage, e.g., from a Type 3 MSD, is illegal within three miles of the U.S. coast). NDZs are also required to have boat pump out facilities. Accordingly, the baseline should represent how much untreated sewage was being discharged to tidal waters within 3 miles and the credit should represent how much sewage discharge is being reduced as a result of pump out stations.

2.0 REGULATORY BACKGROUND

2.1 REGULATORY AUTHORITY

2.1.1 U.S. EPA

With respect to Vessel Sewage Discharges, The United States Environmental Protection Agency (USEPA) regulates the equipment that treats or holds the sewage (marine sanitation devices) and establishes areas in which the discharge of treated and untreated sewage from vessels is not allowed. The USEPA has a website on Vessel Sewage Discharges (USEPA 2015) with links to information on MSDs and NDZs.

2.1.2 U.S Coast Guard

The U.S. Coast Guard governs the design, construction, certification, installation and operation of MSDs, and enforces the NDZ requirements. The U.S Coast Guard has a web page on Marine Sanitation Devices with links to documents and websites related to MSDs. Subtopics on the website included: Changes to International Standards; Laboratory Acceptance; Equipment Approval; Vessel Requirements, and Additional Information (USCG 2016).

2.1.3 State and Local Authority

The following state and local governments have regulatory authority over activities in the Chesapeake Bay and its rivers with respect to NDZs and vessel sewage discharges, and along with USEPA and the Chesapeake Bay Commission, make up the Principal Partners of the Chesapeake Bay Program:

- Commonwealth of Pennsylvania
- Commonwealth of Virginia
- District of Columbia
- State of Delaware
- State of Maryland
- State of New York
- State of West Virginia

2.2 CURRENT REGULATIONS

2.2.1 Clean Water Act

Clean Water Act (CWA) sections 312(a) – (m) provide the statutory framework under which the USEPA and the U.S. Coast Guard regulate sewage discharges from vessels. The CWA prohibits the discharge of untreated vessel waste within three nautical miles of the U.S. coast.

2.2.1.1 No Discharge Zones

Under section 312 of the CWA, vessel sewage may be controlled through the establishment of areas in which discharges of treated sewage from vessels are not allowed. These areas are also known as "no discharge zones" (NDZs). The USEPA has a webpage on *Vessel Sewage Discharges: No Discharge Zones (NDZ)* that provides an overview of the section 312 regulations regarding NDZs (USEPA 2015). Relevant information from this webpage is presented below.

What is an NDZ for vessel sewage?

An NDZ is an area in which both treated and untreated sewage discharges from vessels are prohibited. Within NDZ boundaries, vessel operators are required to retain their sewage discharges onboard for disposal at sea (beyond three miles from shore) or onshore at a pump-out facility.

How is an area designated as an NDZ under the CWA?

The CWA lists three circumstances where a state may initiate the process to establish an NDZ:

1. *The state determines that the water body requires greater environmental protection, and USEPA finds that adequate pump-out facilities are available. (Commonly known as a 312(f)(3) NDZ) A state may completely prohibit sewage discharge from vessels, whether the sewage is treated or not, into some or all of its waters if:*
    a. *The state determines that the protection and enhancement of the quality of the waterbody requires greater environmental protection than the current federal standards allow; and*
    b. *USEPA determines that adequate facilities for the safe and sanitary removal and treatment of sewage from vessels are reasonably available. (33 U.S.C. 1322(f)(3)).*
2. *The USEPA, upon application by the state, determines that the protection and enhancement of the water body requires establishment of an NDZ. (Commonly known as a 312(f)(4)(A) NDZ) If the USEPA determines, upon application by a state, the protection and enhancement of specified waters requires sewage discharges to be prohibited, the USEPA will prohibit, by regulation, sewage discharge from a vessel. This prohibition will occur whether the sewage is treated or not into those waters. Unlike NDZs established pursuant to CWA section 312(f)(3) (described above), the state does not have to show adequate pump-out facilities are reasonably available to request this type of NDZ be established (33 U.S.C.1322(f)(4)(A)).*
3. *Drinking water intake zones. (Commonly known as a 312(f)(4)(B) NDZ) The USEPA, upon application by a state, will prohibit, by regulation, sewage discharge from vessels within a drinking water intake zone. The purpose of this NDZ is to safeguard human health through the protection of intake waters used for drinking. The state does not need to show that adequate pump-out facilities are reasonably available to establish this type of NDZ. (33 U.S.C.1322(f)(4)(B)).*

Who enforces the NDZ requirements?

Under section 312 of the CWA, the U.S. Coast Guard and the state in which the NDZ has been designated may enforce the NDZ requirements. (33 U.S.C. 1322(k)).

How does a vessel operator comply with an NDZ?

The requirements for vessel operators are described in 33 CFR 159.7(b)-(c). The regulations allow for four methods of securing a Type I or II marine sanitation device (MSD) while in an NDZ, including:

- *Closing the seacock and removing the handle;*
- *Padlocking the seacock in the closed position;*
- *Using a non-releasable wire-tie to hold the seacock in the closed position; or*
- *Locking the door to the space enclosing the toilets with a padlock or door handle key lock.*

For Type III devices, the following options are available:

- *Closing valves leading to overboard discharge and removing the handle;*
- *Padlocking any valves leading to overboard discharge in the closed position; or*
- *Holding overboard discharge valves closed using a non-releasable wire-tie.*

Which states have NDZs?

A number of states have designated some or all of their surface waters as NDZs. A list of established NDZs and maps for each may be found at the USEPA webpage No Discharge Zones by State - https://www.epa.gov/vessels-marinas-and-ports/no-discharge-zones-ndzs-state.

2.2.1.2 **Marine Sanitation Devices (MSDs)**

Under section 312 of the CWA, sewage discharges from vessels are controlled in part by regulating the equipment that treats or holds the sewage: marine sanitation devices. The USEPA has a webpage on *Vessel Sewage Discharges: Marine Sanitation Devices (MSDs)* that provides an overview of the section 312 regulations regarding MSDs (USEPA 2015). Relevant information from this webpage is presented below.

What is an MSD?

For purposes of the CWA, an MSD is "any equipment for installation on board a vessel which is designed to receive, retain, treat, or discharge sewage, and any process to treat such sewage." 33 U.S.C. 1322(a)(5).

Who is required to use an MSD?

- *Section 312 of the CWA requires the use of operable, U.S. Coast Guard-certified MSDs on board vessels that are 1) equipped with installed toilets, and 2) operating on U.S. navigable waters (which include the three mile territorial seas). 33 U.S.C. 1322(h)(4).*
- *The MSD requirements do not apply to vessels that do not have installed toilets (e.g., vessels with "porta-potties").*

Who regulates MSDs under section 312?

- *The U.S. Environmental Protection Agency (USEPA) and the U.S. Coast Guard jointly regulate MSDs under CWA section 312.*
- *The USEPA has issued regulations setting performance standards for MSDs (40 CFR 140), which address fecal coliform and total suspended solids.*
- *The Coast Guard has issued regulations (33 CFR 159) governing the design, construction, certification, installation and operation of MSDs, consistent with the USEPA's standards.*
- *To learn more about the Coast Guard's certification requirements for MSDs, please visit the Coast Guard's website.*

Are there different types of MSDs?

Yes, the Coast Guard categorizes MSDs into the three types summarized in

***Table 1**.*

Table 1. MSD Types and Characteristics

Type I	*Flow-through treatment devices that commonly use maceration and disinfection for the treatment of sewage*	*May be installed only on vessels less than or equal to 65 feet in length*	*Must produce an effluent with:* • *No visible floating solids* • *A fecal coliform bacterial count not greater than 1000 per 100 milliliters*
Type II	*Flow-through treatment devices that may employ biological treatment and disinfection (some Type II MSDs may use maceration and disinfection)*	*May be installed on vessels of any length*	*Must produce an effluent with:* • *A fecal coliform bacterial count not greater than 200 per 100 milliliters* • *No more than 150 milligrams of total suspended solids per liter*
Type III	*Typically a holding tank where sewage is stored until it can be disposed of shore-side or at sea (beyond three miles from shore)*	*May be installed on vessels of any length*	*No performance standard; must "be designed to prevent the overboard discharge of treated or untreated sewage or any waste derived from sewage." 33 CFR 159.53(c)).*

What is the role of the states in implementing the CWA section 312 vessel sewage program?

- *Unlike CWA section 402 National Pollutant Discharge Elimination System (NPDES) program, states have a more limited role in implementing the section 312 vessel sewage program.*
- *Except for houseboats (as defined at CWA section 312(f)(1)(B)), states may not adopt or enforce any statute or regulation with respect to the design, manufacture, installation or use of any MSD on any vessel subject to the requirements of section 312. (33 U.S.C. 1322(f)).*
- *States may request that the USEPA establish no discharge zones for vessel sewage (areas in which both treated and untreated sewage discharges from vessels are prohibited). States may establish such zones themselves after required findings are made by the USEPA.*
- *The provisions of section 312 are enforced by the Coast Guard, and may be enforced by the states as well. (33 U.S.C. 1322(k)).*

Are there certain waters where the discharge of treated sewage is prohibited?

- *Yes. Under the CWA and the implementing regulations, vessels are prohibited from discharging any sewage, whether treated by an MSD or not, into the following types of water bodies:*
  - *A water body that has been designated as a no discharge zone.*
  - *Freshwater lakes, reservoirs, or other impoundments whose entrance point(s) and exit point(s) are too shallow to allow vessels with installed toilets to enter and leave.*
  - *Rivers that do not support interstate traffic by vessels subject to section 312. See 40 CFR 140.3(a)(1).*

2.2.1.3 **Implementing Regulations**

The USEPA regulations implementing CWA section 312 (standards for marine sanitation devices (MSDs)) are 40 C.F.R. 140 et seq.

U.S. Coast Guard regulations implementing CWA section 312 (regulations governing the design, construction, certification, installation and operation of MSDs) are 33 C.F.R. 159, Subparts A-D.

2.2.2 MARPOL Annex IV

The principal international instrument regulating sewage discharges from vessels is Annex IV to the "International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto" ("MARPOL Annex IV"). The United States is not a party to MARPOL Annex IV, and thus is not bound by the Annex's provisions. However, ocean-going vessels operating in U.S. navigable waters which are registered in foreign countries may be subject to the MAPROL Annex IV requirements (USEPA 2015).

2.2.3 Clean Vessel Act

Congress passed the Clean Vessel Act (CVA) in 1992 to help reduce pollution from vessel sewage discharges. An overview of the Clean Vessel Act is provided in a brochure published by the U.S. Fish and Wildlife Service, entitled *The Clean Water Act, Keep Our Waters Clean – Use Pumpouts* (USFWS 2016) Relevant information from this brochure is summarized below.

The Act established a five-year federal pumpout grant program administered by the U.S. Fish & Wildlife Service and authorized $40 million from the Sport Fish Restoration Account of the Aquatic Resources Trust Fund for use by the States. Federal funds can constitute up to 75% of all approved projects with the remaining funds provided by the States or marinas.

Reauthorized in 1998, Congress extended the pumpout grant program through 2003, providing $50 million to continue to provide alternatives to overboard disposal of recreational boater sewage.

Currently, vessels use four types of sewage disposal systems. Many people on small boats use portable toilets which can be drained at dump stations, however, vessels over 26 feet in length typically have Marine Sanitation Devices (MSDs). MSDs are available in three forms all of which can hold waste for disposal at a pumpout station.

The U.S. Fish & Wildlife Service established partnerships with the U.S. Coast Guard, the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, marine industry organizations and others to assist with outreach efforts. All nineteen known pumpout manufacturers in North America have taken a voluntary pledge to place the national pumpout symbol on each unit produced in the future.

The Clean Boating Campaign is distributing fact sheets, including one on boat sewage control, which are reproduced and distributed to thousands of boaters across the nation.

Discharging untreated sewage on all fresh waters and any salt waters inside the 3 mile territorial limits of the United States is illegal.

2.2.4 Code of Virginia

The Code of Virginia contains *Regulations Governing the Discharge of Sewage and Other Wastes from Boats (Chapter 21)* and *Commonwealth of Virginia Sanitary Regulations for Marinas and Boat Moorings (Chapter 570)*.

2.2.5 Virginia State Prohibition on Discharges of Vessel Sewage; Final Affirmative Determination

Volume 72 of the Federal Register documents the “Virginia State Prohibition on Discharges of Vessel Sewage; Final Affirmative Determination” (72 FR 34).

It has been determined that adequate facilities for the safe and sanitary removal and treatment of sewage from all vessels are reasonably available for the navigable waters of the Lynnhaven River, Virginia Beach, Virginia. Virginia will completely prohibit the discharge of sewage, whether treated or not, from any vessel in the Lynnhaven River. Another NDZ - Volume 74 No 160 – establishes the same for Broad Creek, Jackson Creek, and Fishing Bay in Middlesex County, VA (note that Virginia also has an NDZ established for Smith Mountain Lake).

2.3 ADDITIONAL RESOURCES

The following resources provide additional information related to MSDs, NDZ's, and regulations related to boat waste management. Some of these resources are from jurisdictions outside of the Chesapeake Bay area, but are still informative to the topic of vessel waste management.

2.3.1 Virginia Department of Health Marina Program

The Virginia Department of Health's (VDH) Marina Program has a mission to… *protect both public health and the environment through regulation, education, and inspection. Our primary focus is making sure that sewage from recreational boaters is disposed of properly, and that facilities for such are adequate.*

The Marina Program oversees regulations that require marinas and other places where boats are moored to have adequate sanitary facilities in order to protect public health and improve water quality.

The Marina Program issues the Certificate to Operate (CTO) and conducts the annual inspection of all Marinas, Other Places Where Boats are Moored and boat ramps. The Marina Program staff cooperates with other state and federal agencies and private sector companies to process applications and review plans for regulatory compliance. The Marina Program also manages the Clean Vessel Act and the Boating Infrastructure Grants, both of which assist marinas in offsetting the cost of installing sanitary sewage collection systems and boating infrastructure.

Their website has a link to the Code of Virginia, Marina Regulations, and other information for marina owners and recreational boaters (VDH 2014).

2.3.2 Maryland DNR Report to Legislature on Marine Sanitation

Maryland Department of Natural Resources (DNR) prepared the *Report to Legislature on Marine Sanitation* in 2000 in response to the Marine Sanitation bills (HB 732 and SB 569; Natural Resource Article §8-742) passed by the Maryland General Assembly in 1999 that required DNR to complete specific tasks related to vessel discharges (MD DNR 2000b).

The report includes results of a boater survey on marine sanitation devices and use of pumpout facilities; results of a Natural Resource Police survey and other data on boat congregation areas; and analysis of areas identified as having living resources that are sensitive to boat sewage discharge. DNR utilized previous studies by consultants, DNR, and the Chesapeake Bay Program in development of the data for this report. DNR was assisted in this effort by representatives of the boating and marine trades community, conservation organizations, and State agencies.

2.3.3 Maryland DNR - No Discharge Zones in Maryland's Waters

The Maryland DNR prepared a white paper entitled No Discharge Zones in Maryland's Waters in 2007 and updated the paper in 2014 (MD DNR 2014). This paper reviews regulations related to NDZs, presents a chronology of Relevant Maryland Statutes and Chesapeake 2000 Objectives, and discussed Maryland DNR's Pumpout Program and Clean Marina Initiative (CMI). The report notes that:

> *In 2007, a total of 452 pumpouts (which empty raw sewage from vessel holding tanks and portable toilets) are currently located at 368 marinas throughout the state. Maryland has more pumpouts than any other state. This remains relatively unchanged in 2014. Most of these marinas received a 100% grant from DNR using a combination of federal Clean Vessel Act (CVA) funds (75%) and state Waterway Improvement Fund (WIF) funds (25%).*

The report explores opportunities for additional NDZs in Maryland.

2.3.4 Salem Sound Marine Sanitation Needs Assessment

The Massachusetts Office of Coastal Zone Management (CZM) published the *Salem Sound Marine Sanitation Needs Assessment Final Report and Guidance Document* in 2005 (MA CZM 2005). This document presents the results of a marine sanitation needs assessment conducted by Salem Sound Coastwatch. The study involved boaters' survey about onboard marine sanitation devices and the use of pumpout facilities.

2.3.5 USEPA- Protecting Coastal Waters from Vessel and Marina Discharges

The USEPA Office of Water published a guidance document in 1994 entitled *Protecting Coastal Waters from Vessel and Marina Discharges, A Guide for State and Local Officials, Volume 1. Establishing No Discharge Areas Under Section 312 of the Clean Water Act* (USEPA 1994). The document provides background information on marine sanitation and vessel sewage, and has detailed guidance on vessel sewage control options.

2.3.6 Fact Sheet 2 Vessel Sewage

Hampton Roads Sanitation District (HRSD) created a fact sheet on Vessel Sewage. It provides a brief summary of federal and state laws regarding vessel sewage and MSDs.

2.3.7 Upper North Shore Regional Boat Waste Pumpout Plan

Massachusetts has a document entitled *Upper North Shore Regional Boat Waste Pumpout Plan* that was developed by the Massachusetts Coastal Zone Management Office (MCZMO 2001). The Plan provides a needs assessment and recommendations for boat waste management in a planning area which encompasses the Parker River/Essex Bay Area of Critical Environmental Concern and the northern waters of Cape Ann. The area includes coastal waters in the towns and cities of Newbury, Rowley, Ipswich, Essex, Gloucester and Rockport.

This Plan summarizes Federal regulations regarding Boat Waste Pumpout. It also notes that locally, some towns have requirements that boats with holding tanks also must be equipped with fittings to allow use of pumpout facilities. Both Rowley and Ipswich have such requirements for boats with mooring/slip permits from the towns. Copies of their requirements are provided in Appendix A of the Plan.

2.3.8 Rhode Island Pumpout Facility Evaluation Report

The Rhode Island Department of Environmental Management Office of Water Resources prepared a *Rhode Island Pumpout Facility Evaluation Report* in 2007 (RIDEM 2007). The state's No Discharge Area program prohibits the discharge of treated and untreated sewage wastes from vessels within three miles of the Rhode Island coast The report summarizes the state's pumpout facilities and pumpout facility inspection program.

2.4 BOAT DISCHARGE MANAGEMENT TIMELINE

Table 2 provides a timeline of implementation measures addressing marine sewage in the U.S. and Chesapeake Bay Watershed.

Table 2. Timeline of Implementation Measures Addressing Marine Sewage

Year	Measure	Description
1972	Clean Water Act (CWA)	Sections 312(a) – (m) provide the statutory framework under which the USEPA and the U.S. Coast Guard regulate sewage discharges from vessels through no discharge zones (NDZs) and marine sanitation devices (MSDs).
1973	MARPOL Annex IV	The principal international instrument regulating sewage discharges from vessels is Annex IV to the "International Convention for the Prevention of Pollution from Ships."
1975	33 CFR – Part 159	U.S. Coast Guard regulations implementing CWA section 312 (regulations governing the design, construction, certification, installation and operation of MSDs)
1976	40 CFR – part 140	The USEPA regulations implementing CWA section 312 (standards for marine sanitation devices (MSDs)). A State may completely prohibit the discharge from all vessels of any sewage, whether treated or not, into some or all of the waters within such State by making a written application to the Administrator, Environmental Protection Agency, and by receiving the Administrator's affirmative determination.
1987	Virginia Administrative Code	Commonwealth of Virginia Sanitary Regulations for Marinas and Boat Moorings. (Chapter 570).
1992	Clean Vessel Act (CVA)	The Clean Vessel Act Grant Program (CVA) provides grant funds to the states, the District of Columbia and insular areas for the construction, renovation, operation, and maintenance of pumpout stations and waste reception facilities for recreational boaters and also for educational programs that inform boaters of the importance of proper disposal of their sewage.
1995	Laws of New York	Navigation. Article 3. §33-e. Marine sanitation devices aboard vessels in vessel waste no-discharge zones.
1999	Laws of New York	Environmental Conservation Law. Article 17. Title 17. §17-1745. Sewage from vessels. Addresses pumpout facilities, NDZs, and CVA grant funds.
2000	Chesapeake 2000	By this agreement, the Executive Committee members commit themselves to nurture and sustain a Chesapeake Bay Watershed Partnership.
2000	Maryland DNR Report to Legislature	This report was prepared in response to the Marine Sanitation bills (HB 732 and SB 569; Natural Resource Article §8-742) passed by the Maryland General Assembly in 1999 that required DNR to complete specific tasks related to vessel discharges. The report includes results of a boater survey on marine sanitation

	on Marine Sanitation	devices and use of pumpout facilities; results of a Natural Resource Police survey and other data on boat congregation areas; and analysis of areas identified as having living resources that are sensitive to boat sewage discharge.
2002	NDZ	First NDZs established in the Chesapeake in Maryland's Herring Bay and Northern Coastal Bays.
2005	Virginia Administrative Code	Regulations Governing the Discharge of Sewage and Other Wastes from Boats. (Chapter 21)
2007	NDZ	NDZ established for the Lynnhaven River in Virginia. (72 FR 7875).
2009	NDZ	NDZ established for Broad Creek, Jackson Creek and Fishing Bay in Virginia. (74 FR 42070).

3.0 LITERATURE REVIEW

A search of published literature was reviewed in preparation for estimating pollutant loads associated with boat discharges. An annotated bibliography follows.

Hänninen, S., & Sassi, J. (2009). ***Estimated nutrient load from waste waters originating from ships in the Baltic Sea area–Updated 2009*. NO VTT-R-07396-08, 20.3. 2009.(2) MEPC 60/INF. 4**

This paper provides information on the proposal to designate the Baltic Sea as a Special Area under MARPOL Annex IV submitted by Denmarks, Estonia, Finland, Germany, Lithuania, Latvia, Poland, the Russian Federation and Sweden. It provides estimates of contributions of marine sewage discharge to total nutrient loads in the Baltic Sea and Gulf of Finland, summarized below.

- Baltic Sea
  - Nitrogen: 356 tons/year, 0.04% of total nitrogen load
  - Phosphorus: 119 tons/year, 0.3% of total phosphorus load
- Gulf of Finland
  - Nitrogen: 52 tons/year, 0.04% of total nitrogen load
  - Phosphorus: 17 tons/year, 0.3% of total phosphorus load

The estimates include the following assumptions:

- Usage of marine craft was based on data collected from ports, ship owners, and various other references.
- No on-board treatment resulting in nitrogen or phosphorus content reduction
- All wastewater discharged into sea
- Nitrogen load from human waste = 15 g/person/day, phosphorus = 5 g/person/day

According to the paper, a similar study was conducted by Knuuttila in 2006, resulting in the following nutrient load estimates:

- 438 tons/year nitrogen from marine discharge
- 99 tons/year phosphorus from marine discharge

OSPAR. (2008). ***OSPAR Commission, 2008: Nutrients in the Convention Area – Assessment of Implementation of PARCOM Recommendations 88/2 and 89/4.*** **Convention for the Protection of**

the Marine Environment of the North-East Atlantic, ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland, and the United Kingdom.

In 2005, The Netherlands estimated the nitrogen and phosphorus loads from marine discharge of sewage from yachts and inland vessels to the north-east Atlantic Ocean. Although their methods and assumptions were not readily available, the following nutrient load estimates were reported:

- Nitrogen: 223 tons/year, 0.35% of total
- Phosphorus: 38 tons/year, 1.0% of total

Baasel-Tillis, P., & Tucker-Carver, J. (1998). Garbage and sewage disposal from recreational boats. *Journal of environmental health*, *61*(4), 8.

According to a national sample of 500 recreational boaters in the USA, 71 percent reported use of Type III MSDs and proper on-shore sewage disposal was reported to occur about 75% of the time.

Leon, L. M., & Warnken, J. (2008). Copper and sewage inputs from recreational vessels at popular anchor sites in a semi-enclosed Bay (Qld, Australia): estimates of potential annual loads. *Marine pollution bulletin*,*57*(6), 838-845.

Twenty popular anchor sites were studied, where 10,000 locally registered recreational craft generated 59,000 vessel nights. The authors assumed little to no use of pump out facilities and estimated the nitrogen load from recreational craft to be 1.17 ± 0.38 tons annually. They also reported highly variable loads, focused at peak holiday times, with 14% associated with the Christmas and Easter holidays.

Geertz-Hansen, O. (2002). Sanitary sewage from pleasure craft in the Baltic Sea. *Danish Environmental Protection Agency*. Cited by The Green Blue Joint Environment Programme. *Sewage and Waste Water Discharges from Boats*. 2009. https://wwwthegreenblue.org.uk%2F~%2Fmedia%2FTheGreenBlue%2FFiles-and-Documents%2FPDF%2Ffact-sheets%2FTGB-Factsheet-02-Sewage.ashx%3Fla%3Den&usg=AFQjCNGNpG8iqAp9aeiqlIw5siJjtowbUw

The authors estimated nutrient loads from pleasure craft in the Baltic Sea, summarized below:

- Nitrogen: 0.017% of total load
- Phosphorus: 0.05% of total phosphorus load

4.0 BASELINE LOAD ESTIMATES

4.1 METHODOLOGY

The recreational boating nutrient load into the Chesapeake Bay was estimated using methods similar to those of Buchart-Horn, Inc. and Versar, Inc. (1992) in the “Survey of the Quantity, Characteristics, and Potential Impacts of Boat Pumpout Waste Generated within the Chesapeake Bay Region of Maryland” that was conducted for the State of Maryland Department of the Environment. The estimate is calculated as a function of 6 key factors:

1) Number of boats operating in the Chesapeake Bay with the ability to use pump-out facilities
2) Annual use days per vessel
3) Duration of trip per use day
4) Number of persons aboard per trip
5) Nutrient output per person per day

6) Pump-out utilization by recreational boaters

Realistic values for each of these factors were developed from available literature as well as from data and information obtained primarily from State representatives on the Panel.

4.2 MARYLAND

4.2.1 Number of Boats operating in the Chesapeake Bay

Maryland boat registration data were provided by Sharon Carrick of the Maryland Department of Natural Resources. The data were separated by county of registration as well as by length and type of boat registered. **Table 3** shows the years of data availability for each of these categories.

Table 3. Maryland Boat Registration Data Availability

Boat Category	Range (years)	Count (years)
Type	1975 – 2015	41
Length	2003 – 2015	13
County of Registration	2011 – 2015	5

Boat length and county of registration trends were quite consistent in terms of relative percentages over the span of available data, so missing data were extrapolated to cover the timeframe of the Chesapeake Bay model, which begins in 1985. A spatial analysis was conducted based on the county registration data and proximity to the bay in order to identify the population most likely to boat in the Chesapeake. A total of 90.9% of vessels are registered in counties within approximately 50 miles of the bay based on the available data from 2011 to 2015. The distribution among counties included in the estimate is summarized in **Table 4** and was used to adjust statewide registration data for proximity and ease of access to the bay.

Table 4. County Distribution of Boat Registrations for Maryland

County/City	Percentage of Total Registered Vessels
Anne Arundel	21.02%
Baltimore County	12.11%
Baltimore City	2.13%
Calvert	4.43%
Caroline	1.33%
Carroll	2.88%
Cecil	3.56%
Charles	3.32%
Dorchester	1.85%
Harford	5.42%

Howard	2.73%
Kent	1.74%
Montgomery	6.04%
Prince George's	3.57%
Queen Anne's	3.88%
Somerset	1.12%
St. Mary's	5.32%
Talbot	3.25%
Wicomico	2.17%
Worcester	3.01%
Total	**90.9%**

4.2.2 Boat Usage

Boat usage metrics were taken from the comprehensive National Recreational Boating Survey produced by the United States Coast Guard (USCG, 2012). **Table 5** describes the metrics for the southern region of the United States that were used to estimate the annual number of person-days spent boating in the Chesapeake Bay by Maryland boaters.

Table 5. USCG Southern Region Boat Usage Statistics

Boat Type	Boating Days/Year	Hours/Day	Persons Onboard
Powerboat	14.1	6.1	2.6
Sailboat	12.8	8.0	2.4

Boating days were prorated according to how many hours were spent on the water each trip, assuming 16 hour days under the consideration that bodily waste is most likely produced during waking hours.

For instance, for powerboat use: $\frac{6.1\ boating\ hrs\ per\ day}{16\ waste\ producing\ hrs\ per\ day} = 0.38\ prorate\ factor$

The number of prorated boating days per year was then multiplied by the number of persons onboard per trip to calculate prorated person-days per year.

4.2.3 Nutrient Output per person per day

The nutrient content of human waste was assumed to be 13 grams N per person per day and 4 grams P per person per day according to Kirscmann et al. (1995) and Hänninen, S., & Sassi, J. (2009), as summarized in **Table 6**.

Table 6. Nutrient Content of Human Excreta

Source	Type of Waste	Min. N (g/p/d)	Max. N (g/p/d)	Min. P (g/p/d)	Max. P (g/p/d)

Kirscmann et al. (1995)	Liquid	6.85	11.78	1.92	2.74
	Solid	1.37	1.92	0.82	1.37
	Total	8.22	13.7	2.74	4.11
Hänninen, S., & Sassi, J. (2009)	Total	12	15	3	5
Assumed for Baseline Estimate	Total	13		4	

4.2.4 Results

Collectively, the key factors described above were used to estimate the potential annual nutrient load from recreational boating in the Chesapeake Bay. A sample calculation using data from 1999 is as follows. Note that this estimate describes the maximum potential nutrient load generated by recreational boating in the Chesapeake Bay by not taking into account any amount of pump-out usage. The full set of Excel calculations are provided in **Appendix A**.

Nitrogen Load from Power boats:

$$162{,}185\ \frac{registered\ boats}{year} * 14.1\ \frac{boating\ days}{registered\ boat} * 0.38\ prorate\ factor * 2.6\ persons\ onboard$$
$$= 2.27\ million\ \frac{person - days}{year} * 13\ \frac{g\ N}{person - day} * \frac{1\ ton}{907{,}185\ g} = 32.5\ \frac{tons\ N}{year}$$

Nitrogen Load from Sail Boats:

$$10{,}818\ \frac{registered\ boats}{year} * 12.8\ \frac{boating\ days}{registered\ boat} * 0.50\ prorate\ factor * 2.4\ persons\ onboard$$
$$= 0.166\ million\ \frac{person - days}{year} * 13\ \frac{g\ N}{person - day} * \frac{1\ ton}{907{,}185\ g} = 2.4\ \frac{tons\ N}{year}$$

Total Nitrogen Load for 1999:

$$32.5\frac{tons}{year}N + 2.4\frac{tons}{year}N = 34.9\frac{tons}{year}N$$

The annual results of the nutrient load baseline estimate are summarized in **Table 7** and **Figure 1**.

Table 7. Range and Mean of Boat Discharge Nutrient Load Estimates for Maryland, 1985-2015

Nutrient	Min (tons)	Max (tons)	Mean (tons)
Nitrogen	26.6	34.9	31.3
Phosphorus	8.17	10.73	9.63

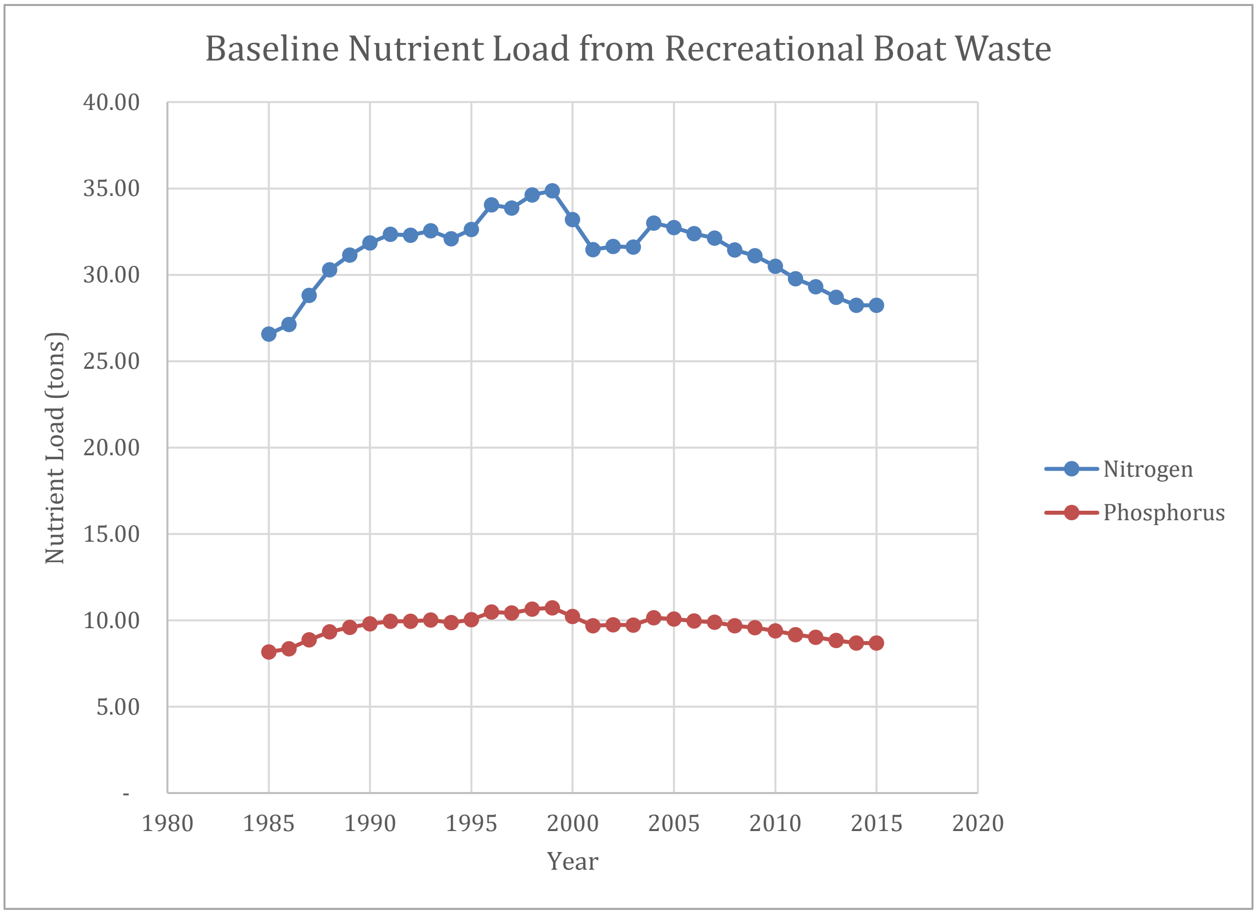

Figure 1. Boat Discharge Nutrient Load Estimates for Maryland, 1985-2015

Finally, in order to increase the resolution of the baseline estimate, monthly variation of boat usage was accounted for according to **Table 8** (Reid, S. et al., 2005).

Table 8. Proportion of Annual Boat Usage by Month

Month	% of Total Annual Boat Usage
January	3.0%
February	3.0%
March	8.5%
April	8.5%
May	8.5%
June	14.5%
July	14.5%
August	14.5%
September	7.5%
October	7.5%

November	7.5%
December	2.5%

4.2.5 Sewage Removal by Boat Pump-outs

Boat size classification data were aggregated into two categories, 16’-21’ and 22’ and greater, according to registration data collected by the contractor and data collected by Buchart-Horn, Inc. and Versar, Inc. (1992) in a marina sewage treatment survey project for the Maryland Department of the Environment. These numbers were also adjusted based on proximity to the Bay in the same manner previously described and it was estimated that 30.8% of boats 16’-21’ and 88% of boats 22’ and greater have the ability to use pump-out facilities (Buchart-Horn, Inc. and Versar, Inc., 1992; and MD DNR, 2000a).

Next, pump-out utilization was estimated by creating a timeline of the total number of pump-out facilities in the state and the date they were installed (MD DNR, 2000b; and O’Neill, D. and Morrow, D., 2014). Assuming that each pump-out installed had an equal effect on increasing utilization, it was ensured that certain statistical milestones were met according to available studies (a maximum utilization rate of 95% was assumed (MD DNR, 2000a)). Using proximity adjusted registration information, likelihood to have an installed sewage holding tank, and estimated pump-out utilization rates, an annual estimate of the number of boats that use pump-out facilities was calculated. Then, similar methods used to estimate the nutrient load in the previous sections were used to estimate potential nutrient removal by boat pump-outs. The results are illustrated in **Table 9** and **Figure 2**.

Table 9. Annual Estimate of Nutrients Removed by Boat Pump-Out Facilities in Maryland

Parameter	Min	Max	Mean
Nitrogen (tons)	0.72	12.07	7.72
Phosphorus (tons)	0.22	3.71	2.38
% Reduction	3%	35%	25%

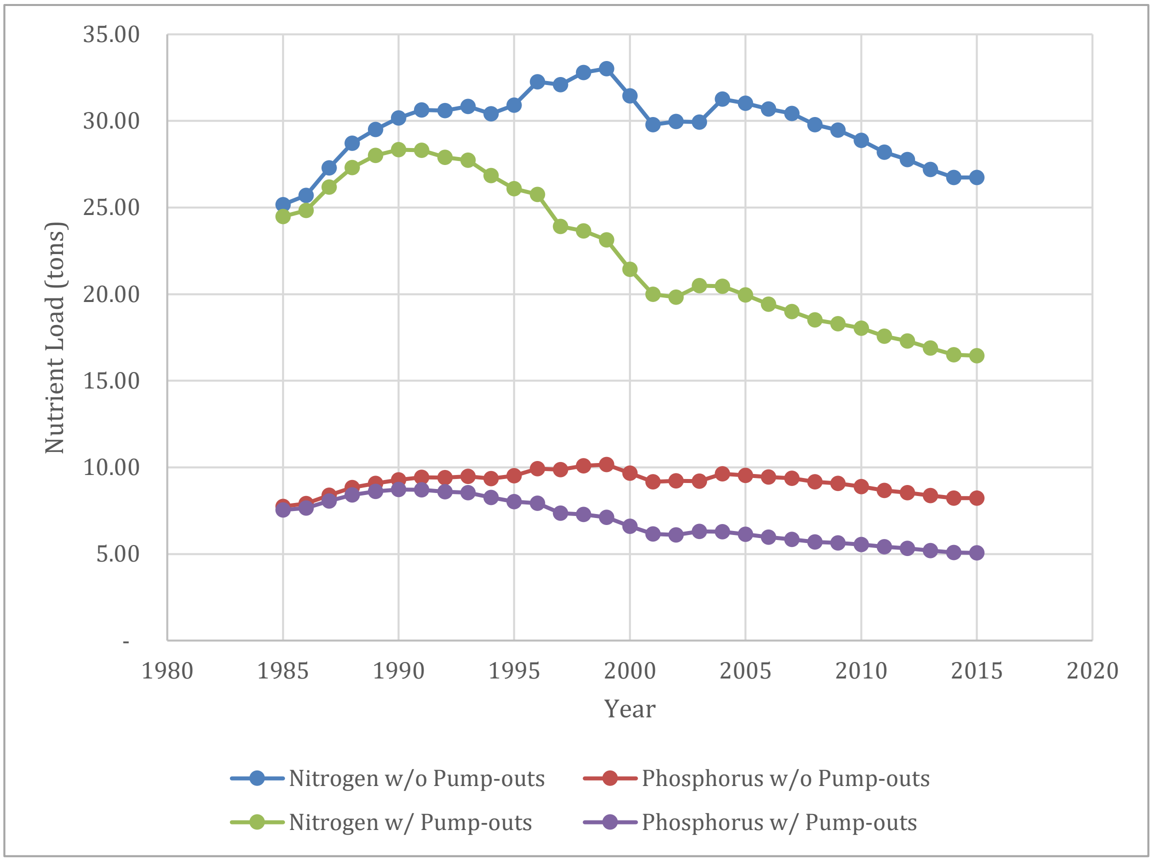

Figure 2. Estimated Nutrient Load Taking into Account Nutrient Removal by Boat Pumpout Facilities, Maryland 1985-2015

4.3 VIRGINIA

4.3.1 Number of Boats operating in the Chesapeake Bay

Virginia boat registration data were provided by the Virginia Department of Game and Inland Fisheries (DGIF). The data were separated by county of registration as well as by length and type of boat registered. **Table 10** shows the years of data availability for each of these categories.

Table 10. Virginia Boat Registration Data Availability

Boat Category	Range (years)	Count (years)
Type	2015	1
Length	2015	1
County of Registration	1997 – 2015	19
Total Registrations	1960-2015	56

A breakdown of Virginia boat registrations by boat length and type was only available for 2015. The boat type breakdown for that year was consistent with the Maryland data, so historical trends were assumed to be similar as well and the Maryland data were used to extrapolate boat type data for prior years. However, there was a substantial difference in the boat length data between Maryland and Virginia in 2015, so the 2015 relative percentages of different length categories were used for all model years. County of registration trends were quite consistent in terms of relative percentages over the span of available data, so missing data were extrapolated to cover the timeframe of the Chesapeake Bay model, which begins in 1985. A spatial analysis was conducted based on the county registration data and proximity to the bay in order to identify the population most likely to boat in the Chesapeake. A total of 66.5% of vessels are registered in counties within approximately 50 miles of the bay based on the available data from 1997 to 2015. The registration distribution among counties was used to adjust statewide registration data for proximity and ease of access to the bay.

4.3.2 Boat Usage

Similarly to the Maryland analysis, boat usage metrics were taken from the comprehensive National Recreational Boating Survey produced by the United States Coast Guard (USCG, 2012), previously summarized in **Table 5**.

Boating days were prorated according to how many hours were spent on the water each trip, assuming 16 hour days under the consideration that bodily waste is most likely produced during waking hours.

For instance, for powerboat use: $\frac{6.1\ boating\ hrs\ per\ day}{16\ waste\ producing\ hrs\ per\ day} = 0.38\ prorate\ factor$

The number of prorated boating days per year was then multiplied by the number of persons onboard per trip to calculate prorated person-days per year.

4.3.3 Nutrient Output per person per day

The nutrient content of human waste was assumed to be 13 grams N per person per day and 4 grams P per person per day according to Kirscmann et al. (1995) and Hänninen, S., & Sassi, J. (2009), as summarized in **Table 6**.

4.3.4 Results

Collectively, the key factors described above were used to estimate the potential annual nutrient load from Virginia recreational boaters in the Chesapeake Bay. A sample calculation using data from 1999 is as follows. Note that this estimate describes the maximum potential nutrient load generated by recreational boating in the Chesapeake Bay by not taking into account any amount of pump-out usage. The full set of Excel calculations are provided in **Appendix B**.

<u>Nitrogen Load from Power boats</u>:

$$132{,}536\ \frac{registered\ boats}{year} * 14.1\ \frac{boating\ days}{registered\ boat} * 0.38\ prorate\ factor * 2.6\ persons\ onboard$$

$$= 1.85\ million\ \frac{person - days}{year} * 13\ \frac{g\ N}{person - day} * \frac{1\ ton}{907{,}185\ g} = 26.5\ \frac{tons\ N}{year}$$

<u>Nitrogen Load from Sail Boats</u>:

$$9{,}619\ \frac{registered\ boats}{year} * 12.8\ \frac{boating\ days}{registered\ boat} * 0.50\ prorate\ factor * 2.4\ persons\ onboard$$

$$= 0.148\ million\ \frac{person - days}{year} * 13\ \frac{g\ N}{person - day} * \frac{1\ ton}{907{,}185\ g} = 2.1\ \frac{tons\ N}{year}$$

<u>Total Nitrogen Load for 1999</u>:

$$26.5\frac{tons}{year}N + 2.1\frac{tons}{year}N = 28.6\frac{tons}{year}N$$

The annual results of the nutrient load baseline estimate are summarized in **Table 11** and **Figure 3**.

Table 11. Range and Mean of Boat Discharge Nutrient Load Estimates for Virginia, 1985-2015

Nutrient	Min (tons)	Max (tons)	Mean (tons)
Nitrogen	20.2	30.2	27.11
Phosphorus	6.21	9.30	8.34

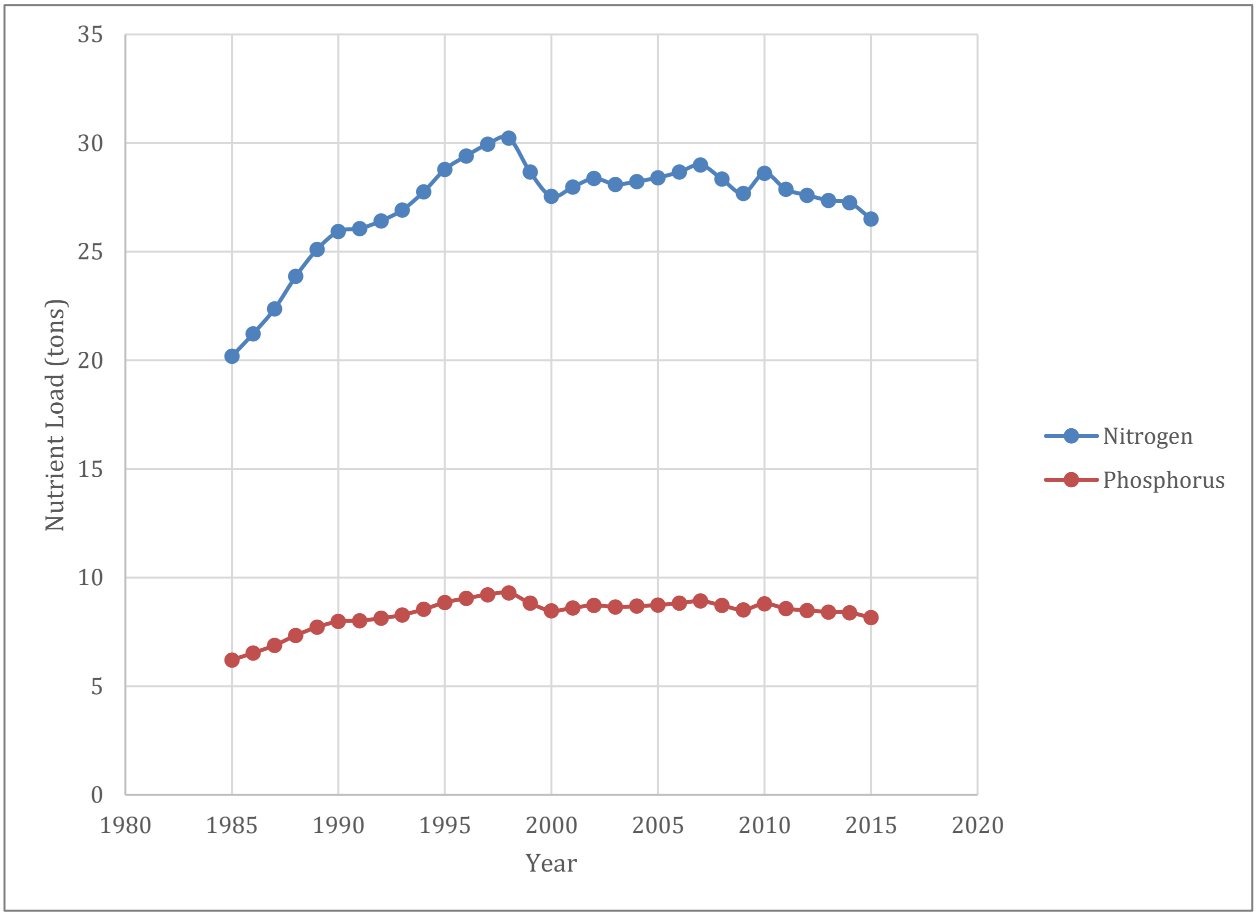

Figure 3. Boat Discharge Nutrient Load Estimates for Virginia, 1985-2015

Finally, in order to increase the resolution of the baseline estimate, monthly variation of boat usage was accounted for according to **Table 8**.

4.3.5 Sewage Removal by Boat Pump-outs

Sewage and associated nutrient removal by boat pump-outs was estimated using methods similar to those used by the City of Virginia Beach in a memorandum delivered to the Virginia Department of Conservation & Recreation. Boat size classification data were aggregated into two categories, 26'-40' and greater than 40', according to the registration data collected by Tetra Tech. These numbers were also adjusted based on proximity to the bay in the same manner described in Section 4.2.5 and it was estimated that 58 percent of boats 26'-40' and all boats greater than 40' have the ability to use pump-out facilities (City of Virginia Beach, 2013; and MD DNR, 2000a). It should be noted that the Virginia Beach estimate assumes that only 25 percent of boats 26'-40' have holding tanks based on 1994 USEPA guidance. The assumption of 58 percent used in this estimate is based on more recent and localized data collected by MD DNR in 2000.

Because there were not sufficient state-level data to create a timeline of pump-out installation in Virginia, pump-out utilization was estimated using Maryland data (refer to Section 4.2.5 for details). Assuming that the vast majority of recreational boating occurs from late spring to early fall, annual pump-out volumes were assessed on the basis of 21 peak weekends per year from early May to late September and a peak occupancy rate of 40% for weekends during the peak boating season (City of Virginia Beach, 2013; and USEPA, 1994). Using proximity adjusted registration information, likelihood to have an installed sewage holding tank, estimated pump-out utilization rates, and a 40% peak occupancy rate, an estimate of the number of boats that use pump-out facilities per weekend during the peak boating season was calculated.

The volume of wastewater removed per pump-out is based on data and records kept by the Hampton Roads Sanitation District (HRSD) as part of their Boater Education and Pump-Out Program. The nutrient content of boat wastewater was based on the Lynnhaven River Boat Wastewater Sampling Program report prepared for the City of Virginia Beach (KCI Lewis White & Associates, 2008). Thus, the total volume of boat wastewater removed by pump-outs in the Chesapeake Bay watershed was estimated by multiplying the number of vessels that require pump-outs per weekend, the number of gallons removed per pump-out, and the number of weekends in the peak boating season. Then, this annual volume was multiplied by the nutrient content of boat wastewater determined by the Lynnhaven study to estimate the annual nutrient load removed by Virginia boat pump-outs in the Chesapeake Bay watershed. A sample calculation for the year 2000 is shown below.

$$3{,}516\ vessels\ that\ can\ use\ pumpouts * 81\%\ pumpout\ utilization\ rate * 40\%\ weekend\ peak\ occupancy\ rate$$

$$= 1{,}139\ \frac{vessels}{weekend} * 19\ \frac{gal}{vessel} * 21\ \frac{weekend}{year}$$

$$= 454{,}563\ \frac{gal}{year} * 0.01387\ \frac{lb\ N}{gal} * \frac{ton}{2{,}000\ lb} = 3.15\ \frac{ton\ N\ removed}{year}$$

The annual results are summarized in **Table 12** and **Figure 4**.

Table 12. Annual Estimate of Nutrients Removed by Boat Pump-Out Facilities in Virginia

Parameter	Min	Max	Mean
Nitrogen (tons)	0.20	4.49	2.47
Phosphorus (tons)	0.01	0.32	0.17
Nitrogen % Reduction	1.0%	14.9%	9.1%
Phosphorus % reduction	0.2%	3.4%	2.1%

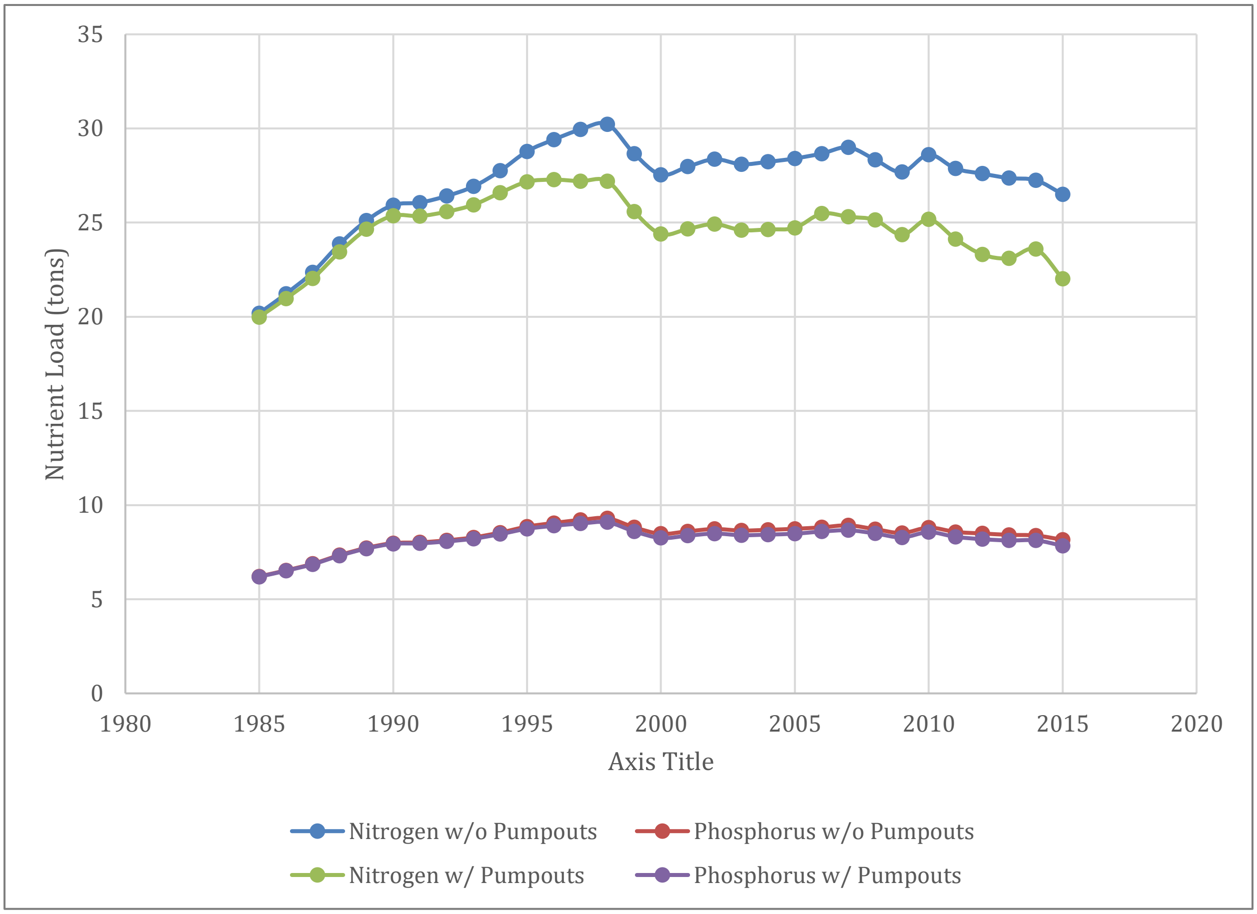

Figure 4. Estimated Nutrient Load Taking into Account Nutrient Removal by Boat Pumpout Facilities, Virginia 1985-2015

5.0 CONCLUSIONS AND RECOMMENDATIONS

Time series nutrient load estimates for presumably the two most significant Bay Watershed boat discharge states have been developed. The Panel recommends that boat discharges be included as a new source in the Bay water quality model. This alone should improve the selection of management actions by Bay partners.

In addition to documenting historical and future loads, the CBP also wants to be able to acknowledge and incentivize good programs that are in place to reduce nutrient loads from boat discharges. Accordingly, the Panel recommends that the development of a boat pump out program be approved as a programmatic BMP. Although each individual pump-out facility installation would not be credited, the programmatic BMP could be part of a jurisdictions' Phase 3 (2018-2025) watershed implementation plans (WIPs) and included as a management target if desired by the jurisdiction.

The methodology described and applied in the Maryland and Virginia estimates provides current baseline tracking, which could also be replicated by other interested states or local jurisdictions. Tracking of future loads and load reductions could use similar methodologies, although metering, other load estimation procedure, an additional future marina survey, etc. may be warranted. The Panel is sensitive to creating verification burdens as the loads and thus potential reduction credits for this practice are low compared to other sources, and the Panel does not want to disincentivize the practice by placing a burden on marina operators, for example, since they have little to gain from nutrient credits. Therefore, the Panel recommends that the CBP would leave the policy details to the states, although multiple verification options are possible, with direct metering being the "gold standard". A summary of the proposed verification protocol in support of the City of Virginia Beach's original Pump Out BMP proposal is provided as an example in **Appendix C**.

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APPENDIX A. MARYLAND CALCULATION WORKSHEETS

year	registered in MD			proximity adjusted[1]		annual use days[2]		prorated annual use days[3], [4]		prorated annual person-days[5]			baseline load estimate[6], [7]			
	total	power	sail	power	sail	power	sail	power	sail	power	sail	total	nitrogen (g)	phosphorus (g)	nitrogen (ton)	phosphorus (ton)
2015	154,145	144,509	9,636	131,328	8,757	1,851,722	112,090	705,969	56,045	1,835,519	134,509	1,970,028	25,610,363	7,880,112	28.23	8.69
2014	154,136	144,432	9,704	131,258	8,819	1,850,735	112,881	705,593	56,441	1,834,541	135,458	1,969,999	25,609,988	7,879,996	28.23	8.69
2013	156,711	146,793	9,918	133,403	9,013	1,880,989	115,371	717,127	57,685	1,864,530	138,445	2,002,975	26,038,677	8,011,901	28.70	8.83
2012	160,038	149,849	10,189	136,181	9,260	1,920,148	118,523	732,056	59,262	1,903,347	142,228	2,045,575	26,592,470	8,182,299	29.31	9.02
2011	162,490	152,042	10,448	138,174	9,495	1,948,249	121,536	742,770	60,768	1,931,202	145,843	2,077,045	27,001,585	8,308,180	29.76	9.16
2010	166,426	155,668	10,758	141,469	9,777	1,994,712	125,142	760,484	62,571	1,977,258	150,170	2,127,429	27,656,575	8,509,715	30.49	9.38
2009	169,735	158,358	11,377	143,914	10,339	2,029,181	132,343	773,625	66,171	2,011,426	158,811	2,170,237	28,213,084	8,680,949	31.10	9.57
2008	171,573	159,900	11,673	145,315	10,608	2,048,941	135,786	781,159	67,893	2,031,012	162,943	2,193,955	28,521,417	8,775,821	31.44	9.67
2007	175,244	163,308	11,936	148,412	10,847	2,092,610	138,845	797,808	69,423	2,074,300	166,614	2,240,914	29,131,882	8,963,656	32.11	9.88
2006	176,722	164,545	12,177	149,536	11,066	2,108,461	141,649	803,851	70,824	2,090,012	169,978	2,259,990	29,379,873	9,039,961	32.39	9.96
2005	178,613	166,162	12,451	151,006	11,315	2,129,181	144,836	811,750	72,418	2,110,551	173,803	2,284,354	29,696,598	9,137,415	32.73	10.07
2004	180,002	167,110	12,892	151,867	11,716	2,141,329	149,966	816,382	74,983	2,122,592	179,959	2,302,551	29,933,161	9,210,204	33.00	10.15
2003	172,583	162,265	10,318	147,464	9,377	2,079,245	120,024	792,712	60,012	2,061,052	144,029	2,205,080	28,666,046	8,820,322	31.60	9.72
2002	172,787	162,504	10,283	147,681	9,345	2,082,308	119,617	793,880	59,808	2,064,088	143,540	2,207,628	28,699,159	8,830,511	31.64	9.73
2001	171,767	161,282	10,485	146,571	9,529	2,066,649	121,966	787,910	60,983	2,048,566	146,360	2,194,926	28,534,035	8,779,703	31.45	9.68
2000	181,166	169,412	11,754	153,959	10,682	2,170,826	136,728	827,627	68,364	2,151,831	164,074	2,315,905	30,106,766	9,263,620	33.19	10.21
1999	190,367	178,463	11,904	162,185	10,818	2,286,805	138,473	871,844	69,236	2,266,795	166,167	2,432,963	31,628,513	9,731,850	34.86	10.73
1998	188,966	176,905	12,061	160,769	10,961	2,266,841	140,299	864,233	70,150	2,247,006	168,359	2,415,365	31,399,742	9,661,459	34.61	10.65
1997	184,890	172,803	12,087	157,041	10,984	2,214,278	140,602	844,194	70,301	2,194,903	168,722	2,363,625	30,727,126	9,454,500	33.87	10.42
1996	185,880	173,616	12,264	157,780	11,145	2,224,696	142,661	848,165	71,330	2,205,230	171,193	2,376,422	30,893,490	9,505,689	34.05	10.48
1995	178,055	166,213	11,842	151,052	10,762	2,129,835	137,752	811,999	68,876	2,111,199	165,302	2,276,500	29,594,506	9,106,002	32.62	10.04
1994	175,113	162,954	12,159	148,090	11,050	2,088,074	141,439	796,078	70,720	2,069,803	169,727	2,239,530	29,113,896	8,958,122	32.09	9.87
1993	177,619	165,352	12,267	150,270	11,148	2,118,802	142,695	807,793	71,348	2,100,262	171,235	2,271,497	29,529,459	9,085,987	32.55	10.02
1992	176,206	163,847	12,359	148,902	11,232	2,099,517	143,766	800,441	71,883	2,081,146	172,519	2,253,665	29,297,644	9,014,660	32.30	9.94
1991	176,439	163,940	12,499	148,986	11,359	2,100,709	145,394	800,895	72,697	2,082,327	174,473	2,256,800	29,338,405	9,027,202	32.34	9.95
1990	173,706	161,170	12,536	146,469	11,393	2,065,214	145,825	787,363	72,912	2,047,144	174,989	2,222,133	28,887,729	8,888,532	31.84	9.80
1989	169,896	157,389	12,507	143,033	11,366	2,016,765	145,487	768,892	72,744	1,999,118	174,585	2,173,703	28,258,137	8,694,811	31.15	9.58
1988	165,231	152,888	12,343	138,943	11,217	1,959,090	143,580	746,903	71,790	1,941,947	172,295	2,114,243	27,485,158	8,456,972	30.30	9.32
1987	157,076	144,988	12,088	131,763	10,985	1,857,860	140,613	708,309	70,307	1,841,604	168,736	2,010,339	26,134,413	8,041,358	28.81	8.86
1986	147,865	136,339	11,526	123,903	10,475	1,747,033	134,076	666,056	67,038	1,731,746	160,891	1,892,637	24,604,280	7,570,548	27.12	8.35
1985	144,795	133,436	11,359	121,265	10,323	1,709,834	132,133	651,874	66,067	1,694,873	158,560	1,853,433	24,094,623	7,413,730	26.56	8.17

notes

(1)	adjustment is based on proximity - approximately 88% of boats registered in Maryland are from counties that are close to the Chesepeake Bay
(2)	in the southern region of the US, powerboats are used an estimated 14.0 days per year while sailboats are used an estimated 12.8 days per year
(3)	prorated to consider that in the southern region of the US, powerboats are used an estimated 6.0 hours per trip while sailboats are used an estimated 8.0 hours per trip
(4)	prorated as 16 hr days under the consideration that waste is most likely produced during waking hours
(5)	in the southern region of the US, there are an estimated 2.6 people aboard per powerboat use day and an estimated 2.4 people aboard per sailboat use day
(6)	based on an estimated excretion of 12 g nitrogen/person/day and 4 g phosphorus/person/day
(7)	1 US ton = 907,185 g

year	size classification			proximity adjusted				pumpout	estimated # of boats that use pumpouts			annual use days		prorated annual use days		prorated annual person-days			estimate of nutrients removed by pumpouts			
	16'-21'	22' - >65'	total	16'-21'	22' - >65'	total	w/ tanks	utilization	total	power	sail	power	sail	power	sail	power	sail	total	nitrogen (g)	phosphorus (g	nitrogen (ton	phosphorus (ton
2015	60,299	49,832	110,131	54,799	45,287	100,086	56,730	0.95	53,894	50,247	3,647	708,486	46,676	270,110	23,338	702,287	56,011	758,299	9,857,882	3,033,194	10.87	3.34
2014	60,182	49,463	109,645	54,693	44,951	99,644	56,402	0.95	53,582	49,957	3,625	704,390	46,406	268,549	23,203	698,227	55,688	753,915	9,800,892	3,015,659	10.80	3.32
2013	60,863	49,641	110,504	55,311	45,113	100,425	56,736	0.95	53,899	50,252	3,647	708,552	46,681	270,135	23,340	702,352	56,017	758,368	9,858,790	3,033,474	10.87	3.34
2012	62,013	50,437	112,450	56,356	45,837	102,193	57,694	0.95	54,809	51,101	3,709	720,522	47,469	274,699	23,735	714,218	56,963	771,181	10,025,351	3,084,724	11.05	3.40
2011	62,791	51,213	114,004	57,064	46,541	103,605	58,532	0.95	55,605	51,843	3,762	730,988	48,159	278,689	24,079	724,591	57,790	782,382	10,170,963	3,129,527	11.21	3.45
2010	64,134	52,332	116,466	58,284	47,559	105,843	59,803	0.95	56,813	52,969	3,844	746,861	49,204	284,741	24,602	740,326	59,045	799,372	10,391,831	3,197,486	11.46	3.52
2009	64,821	54,244	119,065	58,909	49,296	108,205	61,524	0.95	58,448	54,493	3,955	768,357	50,621	292,936	25,310	761,634	60,745	822,379	10,690,928	3,289,516	11.78	3.63
2008	65,620	54,669	120,289	59,635	49,682	109,317	62,088	0.95	58,984	54,993	3,991	775,396	51,084	295,620	25,542	768,612	61,301	829,913	10,788,866	3,319,651	11.89	3.66
2007	67,041	55,343	122,384	60,926	50,295	111,221	63,025	0.95	59,873	55,822	4,051	787,093	51,855	300,079	25,927	780,206	62,226	842,432	10,951,612	3,369,727	12.07	3.71
2006	67,369	55,278	122,647	61,224	50,236	111,460	63,065	0.93	58,950	54,961	3,989	774,954	51,055	295,451	25,528	768,173	61,266	829,439	10,782,713	3,317,758	11.89	3.66
2005	67,912	55,071	122,983	61,718	50,047	111,765	63,051	0.92	57,888	53,971	3,917	760,996	50,136	290,130	25,068	754,337	60,163	814,500	10,588,499	3,258,000	11.67	3.59
2004	67,883	54,851	122,734	61,691	49,848	111,539	62,867	0.90	56,586	52,758	3,829	743,882	49,008	283,605	24,504	737,373	58,810	796,183	10,350,377	3,184,731	11.41	3.51
2003	67,674	46,423	114,097	61,501	42,188	103,690	56,068	0.88	49,379	46,038	3,341	649,132	42,766	247,482	21,383	643,453	51,319	694,772	9,032,031	2,779,087	9.96	3.06
2002	66,548	53,891	120,439	60,478	48,975	109,453	61,725	0.86	53,078	49,486	3,591	697,757	45,969	266,020	22,985	691,652	55,163	746,815	9,708,599	2,987,261	10.70	3.29
2001	66,155	53,573	119,728	60,121	48,686	108,807	61,361	0.84	51,318	47,846	3,472	674,630	44,446	257,203	22,223	668,727	53,335	722,062	9,386,807	2,888,248	10.35	3.18
2000	69,775	56,504	126,279	63,411	51,350	114,761	64,719	0.81	52,422	48,875	3,547	689,139	45,402	262,734	22,701	683,109	54,482	737,591	9,588,678	2,950,363	10.57	3.25
1999	73,319	59,374	132,693	66,631	53,958	120,589	68,006	0.76	51,789	48,285	3,504	680,814	44,853	259,560	22,427	674,857	53,824	728,681	9,472,847	2,914,722	10.44	3.21
1998	72,779	58,937	131,716	66,141	53,561	119,702	67,505	0.71	47,825	44,589	3,236	628,702	41,420	239,693	20,710	623,201	49,704	672,905	8,747,762	2,691,619	9.64	2.97
1997	71,209	57,666	128,875	64,714	52,406	117,120	66,049	0.65	42,830	39,932	2,898	563,044	37,094	214,661	18,547	558,118	44,513	602,631	7,834,200	2,410,523	8.64	2.66
1996	71,591	57,974	129,565	65,061	52,686	117,747	66,403	0.51	34,019	31,717	2,302	447,207	29,463	170,498	14,731	443,294	35,355	478,649	6,222,438	1,914,596	6.86	2.11
1995	68,577	55,534	124,111	62,322	50,468	112,790	63,607	0.40	25,247	23,539	1,708	331,899	21,866	126,536	10,933	328,995	26,239	355,234	4,618,039	1,420,935	5.09	1.57
1994	67,444	54,616	122,060	61,292	49,634	110,927	62,556	0.30	18,623	17,362	1,260	244,811	16,129	93,334	8,064	242,669	19,354	262,023	3,406,301	1,048,093	3.75	1.16
1993	68,409	55,398	123,807	62,169	50,345	112,514	63,452	0.26	16,253	15,154	1,100	213,666	14,077	81,460	7,038	211,796	16,892	228,688	2,972,948	914,753	3.28	1.01
1992	67,865	54,957	122,822	61,675	49,944	111,619	62,947	0.22	14,090	13,137	953	185,232	12,203	70,620	6,102	183,611	14,644	198,255	2,577,314	793,020	2.84	0.87
1991	67,955	55,030	122,984	61,756	50,010	111,767	63,030	0.19	12,218	11,391	827	160,619	10,582	61,236	5,291	159,214	12,698	171,912	2,234,852	687,647	2.46	0.76
1990	66,902	54,177	121,079	60,800	49,236	110,035	62,054	0.15	9,594	8,945	649	126,128	8,310	48,086	4,155	125,025	9,971	134,996	1,754,949	539,984	1.93	0.60
1989	65,435	52,989	118,424	59,466	48,156	107,622	60,693	0.13	7,843	7,313	531	103,108	6,793	39,310	3,396	102,206	8,152	110,358	1,434,651	441,431	1.58	0.49
1988	63,638	51,534	115,172	57,833	46,833	104,667	59,026	0.12	7,356	6,858	498	96,696	6,370	36,865	3,185	95,850	7,645	103,494	1,345,427	413,978	1.48	0.46
1987	60,497	48,991	109,488	54,979	44,522	99,501	56,113	0.10	5,827	5,433	394	76,603	5,047	29,205	2,523	75,933	6,056	81,989	1,065,853	327,955	1.17	0.36
1986	56,949	46,118	103,067	51,755	41,911	93,666	52,822	0.09	4,510	4,205	305	59,291	3,906	22,605	1,953	58,772	4,687	63,460	824,977	253,839	0.91	0.28
1985	55,767	45,160	100,927	50,680	41,041	91,721	51,726	0.07	3,581	3,339	242	47,076	3,101	17,948	1,551	46,664	3,722	50,386	655,013	201,542	0.72	0.22

Load w/ pump-outs	
nitrogen (tons)	phosphorus (tons
17.36	5.34
17.43	5.36
17.84	5.49
18.26	5.62
18.55	5.71
19.03	5.86
19.31	5.94
19.55	6.01
20.04	6.17
20.50	6.31
21.06	6.48
21.59	6.64
21.64	6.66
20.93	6.44
21.11	6.49
22.62	6.96
24.42	7.51
24.97	7.68
25.24	7.76
27.20	8.37
27.53	8.47
28.34	8.72
29.27	9.01
29.45	9.06
29.88	9.19
29.91	9.20
29.57	9.10
28.81	8.87
27.63	8.50
26.21	8.07
25.84	7.95

APPENDIX B. VIRGINIA CALCULATION WORKSHEETS

year	registered in VA			proximity adjusted[1]		annual use days[2]		prorated annual use days[3], [4]		prorated annual person-days[5]			baseline load estimate[6], [7]			
	total	power	sail	power	sail	power	sail	power	sail	power	sail	total	nitrogen (g)	phosphorus (g)	nitrogen (ton)	phosphorus (ton)
2015	197,716	184,338	13,378	122,587	8,896	1,728,475	113,875	658,981	56,937	1,713,350	136,650	1,850,000	24,050,002	7,400,001	26.51	8.16
2014	203,232	189,481	13,751	126,007	9,145	1,776,697	117,052	677,366	58,526	1,761,151	140,462	1,901,613	24,720,963	7,606,450	27.25	8.38
2013	204,076	190,268	13,808	126,530	9,183	1,784,075	117,538	680,179	58,769	1,768,464	141,045	1,909,510	24,823,627	7,638,039	27.36	8.42
2012	205,830	191,903	13,927	127,618	9,262	1,799,409	118,548	686,025	59,274	1,783,664	142,258	1,925,922	25,036,982	7,703,687	27.60	8.49
2011	207,854	193,790	14,064	128,873	9,353	1,817,103	119,714	692,771	59,857	1,801,204	143,656	1,944,860	25,283,179	7,779,440	27.87	8.58
2010	213,357	198,921	14,436	132,285	9,600	1,865,212	122,883	711,112	61,442	1,848,891	147,460	1,996,351	25,952,559	7,985,403	28.61	8.80
2009	206,484	192,513	13,971	128,023	9,291	1,805,126	118,925	688,204	59,462	1,789,331	142,710	1,932,041	25,116,534	7,728,164	27.69	8.52
2008	211,370	197,068	14,302	131,053	9,511	1,847,841	121,739	704,489	60,869	1,831,672	146,086	1,977,759	25,710,862	7,911,035	28.34	8.72
2007	216,260	201,627	14,633	134,084	9,731	1,890,590	124,555	720,787	62,278	1,874,047	149,466	2,023,514	26,305,678	8,094,055	29.00	8.92
2006	213,773	199,309	14,464	132,542	9,619	1,868,848	123,123	712,498	61,561	1,852,496	147,747	2,000,243	26,003,161	8,000,973	28.66	8.82
2005	211,859	197,524	14,335	131,356	9,533	1,852,116	122,020	706,119	61,010	1,835,910	146,424	1,982,334	25,770,344	7,929,337	28.41	8.74
2004	210,531	196,286	14,245	130,532	9,473	1,840,506	121,256	701,693	60,628	1,824,402	145,507	1,969,908	25,608,807	7,879,633	28.23	8.69
2003	209,563	195,383	14,180	129,932	9,430	1,832,044	120,698	698,467	60,349	1,816,013	144,838	1,960,851	25,491,060	7,843,403	28.10	8.65
2002	211,568	197,253	14,315	131,175	9,520	1,849,572	121,853	705,149	60,926	1,833,388	146,223	1,979,611	25,734,947	7,918,445	28.37	8.73
2001	208,630	194,514	14,116	129,354	9,388	1,823,887	120,161	695,357	60,080	1,807,928	144,193	1,952,121	25,377,571	7,808,483	27.97	8.61
2000	205,439	191,539	13,900	127,375	9,244	1,795,991	118,323	684,721	59,161	1,780,276	141,987	1,922,263	24,989,421	7,689,053	27.55	8.48
1999	213,763	199,299	14,464	132,536	9,619	1,868,761	123,117	712,465	61,558	1,852,409	147,740	2,000,150	26,001,945	8,000,598	28.66	8.82
1998	225,448	210,194	15,254	139,781	10,144	1,970,914	129,847	751,411	64,923	1,953,668	155,816	2,109,484	27,423,298	8,437,938	30.23	9.30
1997	223,334	208,223	15,111	138,470	10,049	1,952,433	128,629	744,365	64,315	1,935,349	154,355	2,089,704	27,166,153	8,358,816	29.95	9.21
1996	219,338	204,497	14,841	135,993	9,869	1,917,499	126,328	731,046	63,164	1,900,721	151,594	2,052,314	26,680,083	8,209,256	29.41	9.05
1995	214,675	200,150	14,525	133,102	9,660	1,876,734	123,642	715,505	61,821	1,860,312	148,371	2,008,683	26,112,880	8,034,732	28.78	8.86
1994	206,983	192,978	14,005	128,333	9,313	1,809,489	119,212	689,868	59,606	1,793,656	143,054	1,936,710	25,177,232	7,746,840	27.75	8.54
1993	200,773	187,188	13,585	124,482	9,034	1,755,200	115,635	669,170	57,818	1,739,842	138,762	1,878,604	24,421,853	7,514,416	26.92	8.28
1992	196,999	183,670	13,329	122,142	8,864	1,722,206	113,462	656,591	56,731	1,707,137	136,154	1,843,291	23,962,786	7,373,165	26.41	8.13
1991	194,387	181,234	13,153	120,523	8,747	1,699,372	111,957	647,886	55,979	1,684,502	134,349	1,818,851	23,645,065	7,275,405	26.06	8.02
1990	193,401	180,315	13,086	119,911	8,702	1,690,752	111,389	644,599	55,695	1,675,958	133,667	1,809,625	23,525,129	7,238,501	25.93	7.98
1989	187,214	174,547	12,667	116,075	8,424	1,636,664	107,826	623,978	53,913	1,622,343	129,391	1,751,734	22,772,548	7,006,938	25.10	7.72
1988	177,962	165,921	12,041	110,339	8,008	1,555,781	102,497	593,142	51,249	1,542,168	122,997	1,665,165	21,647,142	6,660,659	23.86	7.34
1987	166,793	155,507	11,286	103,414	7,505	1,458,139	96,065	555,916	48,032	1,445,381	115,277	1,560,658	20,288,555	6,242,632	22.36	6.88
1986	158,289	147,579	10,710	98,142	7,122	1,383,796	91,167	527,572	45,583	1,371,687	109,400	1,481,087	19,254,136	5,924,349	21.22	6.53
1985	150,545	140,359	10,186	93,340	6,774	1,316,096	86,707	501,762	43,353	1,304,580	104,048	1,408,628	18,312,162	5,634,512	20.19	6.21

year	size classification			proximity adjusted				pumpout	peak	vessels requiring	gal. pumped	peak weekends	gal. pumped per year	nutrient conc. in boat WW (lb/gal)		estimate of nutrients removed by pumpouts	
	26'-40'	>40'	total	26'-40'	>40'	total	w/ tanks	utilization	occupancy	pumpouts/wknd	per vessel	per year	(peak season only)	nitrogen	phosphorus	nitrogen (ton)	phosphorus (ton)
2015	8,015	308	8,323	5,330	293	5,623	3,384	95%	40%	1,286	24	21	648,111	0.01387	0.00098	4.49	0.32
2014	8,239	317	8,555	5,479	301	5,780	3,478	95%	40%	1,322	19	21	527,402	0.01387	0.00098	3.66	0.26
2013	8,273	318	8,591	5,502	302	5,804	3,493	95%	40%	1,327	22	21	613,212	0.01387	0.00098	4.25	0.30
2012	8,344	321	8,665	5,549	305	5,853	3,523	95%	40%	1,339	22	21	618,483	0.01387	0.00098	4.29	0.30
2011	8,426	324	8,750	5,603	308	5,911	3,558	95%	40%	1,352	19	21	539,396	0.01387	0.00098	3.74	0.26
2010	8,649	332	8,981	5,752	316	6,067	3,652	95%	40%	1,388	17	21	495,395	0.01387	0.00098	3.44	0.24
2009	8,370	322	8,692	5,566	306	5,872	3,534	95%	40%	1,343	17	21	479,437	0.01387	0.00098	3.32	0.23
2008	8,569	329	8,898	5,698	313	6,011	3,618	95%	40%	1,375	16	21	461,912	0.01387	0.00098	3.20	0.23
2007	8,767	337	9,104	5,830	320	6,150	3,701	95%	40%	1,407	18	21	531,673	0.01387	0.00098	3.69	0.26
2006	8,666	333	8,999	5,763	316	6,079	3,659	93%	40%	1,368	16	21	459,666	0.01387	0.00098	3.19	0.22
2005	8,588	330	8,918	5,711	314	6,025	3,626	92%	40%	1,332	19	21	531,339	0.01387	0.00098	3.68	0.26
2004	8,534	328	8,862	5,676	312	5,987	3,603	90%	40%	1,297	19	21	517,646	0.01387	0.00098	3.59	0.25
2003	8,495	326	8,822	5,649	310	5,960	3,587	88%	40%	1,264	19	21	504,156	0.01387	0.00098	3.50	0.25
2002	8,577	330	8,906	5,703	313	6,017	3,621	86%	40%	1,246	19	21	496,964	0.01387	0.00098	3.45	0.24
2001	8,457	325	8,782	5,624	309	5,933	3,571	84%	40%	1,195	19	21	476,633	0.01387	0.00098	3.31	0.23
2000	8,328	320	8,648	5,538	304	5,842	3,516	81%	40%	1,139	19	21	454,563	0.01387	0.00098	3.15	0.22
1999	8,666	333	8,999	5,763	316	6,079	3,659	76%	40%	1,114	19	21	444,683	0.01387	0.00098	3.08	0.22
1998	9,139	351	9,490	6,078	334	6,411	3,859	71%	40%	1,093	19	21	436,304	0.01387	0.00098	3.03	0.21
1997	9,054	348	9,401	6,021	331	6,351	3,823	65%	40%	991	19	21	395,608	0.01387	0.00098	2.74	0.19
1996	8,892	342	9,233	5,913	325	6,238	3,754	51%	40%	769	19	21	306,952	0.01387	0.00098	2.13	0.15
1995	8,702	334	9,037	5,787	318	6,105	3,674	40%	40%	583	19	21	232,763	0.01387	0.00098	1.61	0.11
1994	8,391	322	8,713	5,580	306	5,886	3,543	30%	40%	422	19	21	168,317	0.01387	0.00098	1.17	0.08
1993	8,139	313	8,452	5,412	297	5,710	3,436	26%	40%	352	19	21	140,486	0.01387	0.00098	0.97	0.07
1992	7,986	307	8,293	5,311	292	5,602	3,372	22%	40%	302	19	21	120,459	0.01387	0.00098	0.84	0.06
1991	7,880	303	8,183	5,240	288	5,528	3,327	19%	40%	258	19	21	102,932	0.01387	0.00098	0.71	0.05
1990	7,840	301	8,141	5,214	286	5,500	3,310	15%	40%	205	19	21	81,684	0.01387	0.00098	0.57	0.04
1989	7,589	292	7,881	5,047	277	5,324	3,204	13%	40%	166	19	21	66,089	0.01387	0.00098	0.46	0.03
1988	7,214	277	7,491	4,798	263	5,061	3,046	12%	40%	152	19	21	60,579	0.01387	0.00098	0.42	0.03
1987	6,761	260	7,021	4,496	247	4,743	2,855	10%	40%	119	19	21	47,315	0.01387	0.00098	0.33	0.02
1986	6,417	247	6,663	4,267	234	4,501	2,709	9%	40%	93	19	21	36,920	0.01387	0.00098	0.26	0.02
1985	6,103	235	6,337	4,058	223	4,281	2,577	7%	40%	71	19	21	28,470	0.01387	0.00098	0.20	0.01

Load w/ pump-outs	
nitrogen (tons)	phosphorus (tons)
22.02	7.84
23.59	8.13
23.11	8.12
23.31	8.19
24.13	8.31
25.17	8.56
24.36	8.28
25.14	8.49
25.31	8.66
25.48	8.60
24.72	8.48
24.64	8.43
24.60	8.40
24.92	8.49
24.67	8.37
24.39	8.25
25.58	8.60
27.20	9.09
27.20	9.02
27.28	8.90
27.17	8.74
26.59	8.46
25.95	8.21
25.58	8.07
25.35	7.97
25.37	7.94
24.64	7.69
23.44	7.31
22.04	6.86
20.97	6.51
19.99	6.20

APPENDIX C. VIRGINIA BEACH LYNNHAVEN VERIFICATION PROPOSAL