This document is part of Appendix A, and includes Seawater Cooling Overboard Discharge: Nature of Discharge for the "Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS)," published in April 1999. The reference number is EPA-842-R-99-001.

Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS)

Seawater Cooling Overboard Discharge: Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Seawater Cooling Overboard Discharge

1.0 INTRODUCTION

The National Defense Authorization Act of 1996 amended Section 312 of the Federal Water Pollution Control Act (also known as the Clean Water Act (CWA)) to require that the Secretary of Defense and the Administrator of the Environmental Protection Agency (EPA) develop uniform national discharge standards (UNDS) for vessels of the Armed Forces for "...discharges, other than sewage, incidental to normal operation of a vessel of the Armed Forces, ..." [Section 312(n)(1)]. UNDS is being developed in three phases. The first phase (which this report supports), will determine which discharges will be required to be controlled by marine pollution control devices (MPCDs)—either equipment or management practices. The second phase will develop MPCD performance standards. The final phase will determine the design, construction, installation, and use of MPCDs.

A nature of discharge (NOD) report has been prepared for each of the discharges that has been identified as a candidate for regulation under UNDS. The NOD reports were developed based on information obtained from the technical community within the Navy and other branches of the Armed Forces with vessels potentially subject to UNDS, from information available in existing technical reports and documentation, and, when required, from data obtained from discharge samples that were collected under the UNDS program.

The purpose of the NOD report is to describe the discharge in detail, including the system that produces the discharge, the equipment involved, the constituents released to the environment, and the current practice, if any, to prevent or minimize environmental effects. Where existing process information is insufficient to characterize the discharge, the NOD report provides the results of additional sampling or other data gathered on the discharge. Based on the above information, the NOD report describes how the estimated constituent concentrations and mass loading to the environment were determined. Finally, the NOD report assesses the potential for environmental effect. The NOD report contains sections on: Discharge Description, Discharge Characteristics, Nature of Discharge Analysis, Conclusions, and Data Sources and References.

2.0 DISCHARGE DESCRIPTION

This section describes discharges from seawater cooling systems and includes information on: the equipment that is used and its operation (Section 2.1), general description of the constituents of the discharge (Section 2.2), and the vessels that produce this discharge (Section 2.3).

2.1 Equipment Description and Operation

Seawater cooling systems on surface ships and submarines provide cooling water for heat exchangers, removing heat from the propulsion plant and mechanical auxiliary systems. Heat exchangers are provided for steam, diesel, and gas turbine propulsion plants and electric generating plants; air-conditioning (A/C) plants; air compressors; and electronic equipment. Seawater is provided to steam propulsion plants for the purpose of condensing exhausted steam from propulsion or electric generator turbines before the condensate is cycled back to boilers or steam generators.

Seawater cooling systems draw seawater either directly from hull connections (sea chests), or indirectly from the firemain that is supplied directly from a hull connection. The seawater is pumped through heat exchangers where it absorbs heat and is then discharged overboard at a higher temperature. At sea, the demands for seawater cooling are higher than pierside or at anchor because systems requiring seawater cooling tend to be in use and at a higher power output level while underway. Even while pierside, however, the demands for cooling of auxiliary systems may be significant. Conventional steam vessels were estimated to have a 24-hour start-up and securing cycle and nuclear vessels a 48-hour start-up and securing cycle.[1]

Typically, the demand for cooling water is continuous. The residence time of seawater in seawater cooling systems is relatively short, perhaps a minute or two for most portions of the cooling system. Some branch piping, however, may have relatively long residence times due to inactivity of equipment.[2]

Seawater cooling systems are designed to minimize flow-induced erosion of the piping system. The piping systems, where possible, have geometry (e.g., increase turn or elbow radii) or sizing to minimize turbulent flow. The materials of construction (e.g., copper, nickel, and titanium) are selected because of their resistance to seawater corrosion. Sea chests, heat exchangers, and other components could also contain sacrificial material such as waster pieces or zinc anodes to protect the system from corrosion.

Many boats and craft such as utility landing craft and rigid inflatable boats use keel coolers or stern flushing tubes.[1] Keel coolers use ship’s motion to pass water over exposed heat transfer coils in a recessed area of the boat keel. Stern flushing tubes are simple cooling systems in which engine cooling water is drawn from a hull connection and is discharged from the vessel’s stern, normally above the water line.

Sea chests and hull connections are equipped with sea strainer plates to prevent debris from entering the seawater cooling system (especially when in port or in coastal waters) and causing failures due to clogging.[3] The openings in these strainer plates vary in diameter from 1/4 inch to 1-1/2 inches and require periodic blowdowns to prevent clogging. This is accomplished by blowing low-pressure air or steam out through the plates.[3]

Some vessels add biofouling prevention chemicals to the seawater.[1,4] The contribution of anti-fouling additives to seawater cooling overboard discharge is addressed in the Seawater Piping Biofouling Prevention NOD report and will not be considered in this report.

In addition to seawater cooling while pierside, Navy vessels with non-conventional steam propulsion also fill their main steam condenser heat exchangers with fresh water if the vessel is going to be in port for an extended period. When vessels are in port for an extended period of time, they often deactivate their propulsion plants. During these periods, the main condenser is filled with fresh water because fresh water inhibits biofouling.[1] Freshwater layups for non-conventional main steam condenser heat exchangers are discussed in the Freshwater Layup NOD report.

2.2 Releases to the Environment

The releases to the environment consist of the seawater discharged overboard from the seawater cooling system with entrained or dissolved materials from the components of the seawater cooling system and bottom sediments that are brought onboard through the sea chest. The components of the seawater cooling system include: the sea chest, pumps, heat exchangers, pipes, fittings, and valves. The sea chests are constructed of steel and are painted with high durable epoxy paints, and they also contain steel or zinc sacrificial material.[1] The pumps are constructed of titanium, stainless steel, nickel alloys, bronze, and non-metallic composites.[1] Heat exchangers are copper-nickel alloys or titanium.[1] The pipes and fittings in seawater systems are primarily copper-nickel alloys, but fittings may also be bronze with silver-brazed joints.[1] Valves are constructed of bronze, nickel alloys, or aluminum alloys.[1] Some traces of hydraulic oil or other lubricants may enter the seawater from remotely operated valves or pumps. The metals that may enter the seawater include copper, nickel, lead, aluminum, tin, silver, iron, titanium, chromium, and zinc.

In addition, the discharge constitutes a thermal load. The maximum discharge temperature is 140 degrees Fahrenheit (°F) to prevent formation of soft scale (calcium carbonate) inside the pipes and heat exchangers.[1] The difference in temperature from influent to effluent is usually between 10 °F to 15 °F, but the range can be as much as 5 °F to 25 °F.[5]

Sea strainer plate blowdown consists of air or steam, and any solids blown off the strainer plate. Air bubbles rise to the surface and dissipate, while the solids fall to the bottom. Solids can include anything that has been held against the plate by the cooling water suction (e.g., debris and mud) plus biota that has grown on the plate over time (e.g., sea grass and slime).

2.3 Vessels Producing the Discharge

Ships, boats, and craft in the Navy, Military Sealift Command (MSC), U.S. Coast Guard (USCG), Army, and Air Force with the exception of some non-self propelled service craft such as barges, use seawater for cooling. Of the over 6,000 ships, boats, and craft in the Armed Forces, the vast majority of these vessels (over 5,000) consists of boats and craft. The majority of the seawater cooling overboard discharge, however, is generated by larger ships and vessels that have large, continuous seawater cooling demands. There are 673 such surface ships and submarines. The boats and craft in service use either intermittent cooling water or have keel coolers where there is no flow through the vessel. Table 1 lists the vessels that contribute to this discharge and the estimates for the number of transits, number of days in port, and number of days operating within 12 nautical miles (n.m.) by each ship class each year.

3.0 DISCHARGE CHARACTERISTICS

This section contains qualitative and quantitative information that characterizes the discharge. Section 3.1 describes where the discharge occurs with respect to harbors and near-shore areas, Section 3.2 describes the rate of the discharge, Section 3.3 lists the constituents in the discharge, and Section 3.4 gives the concentrations of the constituents in the discharge.

3.1 Locality

This discharge occurs both within and beyond 12 n.m. of shore.

3.2 Rate

Seawater cooling flow rates can vary from several gallons per minute (gpm) for smaller, diesel-powered ships to flows of greater than 170,000 gpm for aircraft carriers during full-power steaming. While transiting, vessels tend to operate at levels sufficient to maintain steering control and do not require the maximum amount of seawater cooling. While anchored or pierside, seawater cooling flow rates are at their lowest because only certain auxiliary equipment is required. Table 2 lists examples of typical pierside and transit steaming flow rates for vessel classes.[6]

Tables 3a, 3b, and 3c provide estimates of discharge flow rates for various ship classes within 12 n.m. of shore based on available data. The number of transits were used to estimate the number of light-off and securing cycles for steam-powered vessels. The calculations use a typical transit time of 4 hours between 0 to 12 n.m.[7] For USCG vessels, operation within 12 n.m. of shore includes seawater cooling flow rates at pierside rates for 16 hours each day with the remaining 8 hours at typical underway flow rates. An example for the estimated annual flow of the WAGB 399 Class for operation within 12 n.m. of shore is calculated by the equation:

Estimated Annual Flows (gal), Operating Within 12 n.m. = (Qty)(Operating Time)(60) [(16/24)(Pierside Flow) + (8/24)(Operating Flow)] WAGB 399 Annual Flow (gal), Operating Within 12 n.m. = (2)(2400 hrs)(60 min/hr) [(16/24)(800 gal/min) + (8/24)(4000)] = 537,600,000 gal

Based on these estimates, the total annual flow of seawater cooling overboard discharge from Navy, MSC, Army, and USCG vessels is estimated as 390 billion gallons. Flow rates for Air Force vessels are not estimated.

3.3 Constituents

Seawater cooling overboard discharge is primarily seawater that contains trace materials from seawater cooling system pipes, fittings, valves, seachests, pumps, and heat exchangers. The expected constituents of seawater cooling discharge include copper, iron, aluminum, zinc, nickel, tin, titanium, arsenic, manganese, chromium, lead, and possibly oil and grease from valves and pumps. Of the constituents expected to be present in this discharge, arsenic, chromium, copper, lead, nickel, and zinc are priority pollutants. None of the expected constituents is a bioaccumulator.

The constituents from strainer plate blowdown include the material ejected from the strainer plate, such as biota, mud, or debris, trapped from the sea or harbor waters.

3.4 Concentrations

Influent and effluent samples were collected from the seawater cooling systems of five ships.[8] A summary of the analytical results are presented in Table 4. This table shows the constituents, the log-normal mean, the frequency of detection for each constituent, the minimum and maximum concentrations, and the mass loadings of each constituent. For the purposes of calculating the log-normal mean, a value of one-half the detection limit was used for non-detected results.

The analytical data for a Coast Guard vessel were not used to calculate the log-normal mean concentrations in Table 4 because the data indicated a large average net decrease in effluent concentrations for total copper, nickel, tin, and zinc. For example, data for this vessel varied widely for total copper with an average influent concentration of 1,450 μg/L and an average effluent concentration of 419 μg/L, a net decrease of 1,031 μg/L. These concentrations are one to two orders of magnitude higher than data from the other ships. The Coast Guard vessel data were considered an anomaly and were excluded from log-normal mean concentration calculations to avoid biasing the data with large, negative net concentrations.

Variability is expected within this discharge as a result of several factors including material erosion and corrosion, residence times, passive films, and influent water variability. Pipe erosion is caused by high fluid velocity, or by abrasive particles entrained in the seawater flowing at any velocity. In most cases of pipe erosion, the problematic high fluid velocity is a local phenomenon, such as would be caused by eddy turbulence at joints, bends, reducers, attached mollusks, or tortuous flow paths in valves. Passive films inhibit metal loss due to erosion. Corrosion is influenced by the residence time of seawater in the system, temperature, biofouling, constituents in the influent, and the presence or absence of certain films on the pipe surface. All of these influences on metallic concentrations are variable within a given ship over time, and between ships.

4.0 NATURE OF DISCHARGE ANALYSIS

Based on the discharge characteristics presented in Section 3.0, the nature of the discharge and its potential impact on the environment can be evaluated. The estimated mass loadings are presented in Section 4.1. In Section 4.2, the concentrations of discharge constituents after release to the environment are estimated and compared with the water quality criteria. Section 4.3 discusses thermal effects. In Section 4.4, the potential for the transfer of non-indigenous species is discussed.

4.1 Mass Loadings

Based on the discharge volume estimates developed in Tables 3a, 3b and 3c and the log-normal mean discharge concentrations and mass loadings are presented in Table 4. Table 5 is present in order to highlight constituents with log-normal mean concentrations that exceed water quality criteria (WQC). A sample calculation of the estimated annual mass loading for copper is shown here:

Mass Loading for Copper (Total)

Mass Loading = (Net Positive Log-normal Mean Concentration)(Flow Rate)

$(34.49\ \mu g/L)(3.785\ L/gal)(390{,}000{,}000{,}000\ gal/yr)(2.202\ lbs/kg)(10^{-9}\ kg/\mu g) \cong 112{,}100\ lbs/yr$

4.2 Environmental Concentrations

The log-normal mean discharge concentrations are compared to the Federal and most stringent state WQC in Table 6. Copper exceeds the Federal and most stringent state WQC. This can be attributed to two factors: 1) the copper concentrations of many harbors exceed the standard, and 2) other copper sources (e.g. copper hull coatings) of the vessel are located near the influent sea chest. Between 1 and 90 µg/L of copper naturally occurs in seawater.[9] Nickel and silver concentrations also exceed the Federal and most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen) exceeds the most stringent state WQC.

4.3 Thermal Effects

The potential for seawater cooling overboard discharge to cause thermal environmental effects was evaluated by modeling the thermal plume generated under conditions tending to produce the greatest temperature rise and then compared to state plume thermal discharge requirements. Thermal effects of seawater cooling water overboard discharge were modeled using the Cornell Mixing Zone Expert System (CORMIX) to estimate the plume size and temperature gradients in the receiving water body. Thermal modeling was performed for three ships in three harbors (Mayport, FL; Norfolk, VA; and Bremerton, WA) to assess the potential thermal impact. The discharge was also assumed to occur during winter when the ambient water temperatures are lowest. Based on these models, Navy aircraft carriers are predicted to generate thermal plumes that, under conditions of low harbor flushing, low wind velocities, and maximum cooling water flow rates, would exceed the regulatory limits of Washington.[5] Thermal plumes from models of smaller ships (destroyers) do not exceed regulatory limits.[5] Of the five states having a substantial presence of Armed Forces' vessels, only Virginia and Washington have established thermal mixing zone dimensions.

4.4 Potential for Introducing Non-Indigenous Species

The seawater cooling water system has a minimal potential for transporting non-indigenous species, because the residence times for most portions of the system are short. Some portions of the seawater system lie stagnant where marine organisms may reside. However, these areas tend to develop anaerobic conditions quickly, except at the junctions with the active portions of the system, where oxygenated water continuously flows by and through the ship. The seawater is not a system where large volumes of water, under aerobic conditions, are transported over distances.

A small potential exists for transport of non-indigenous species because the blowdown procedure for the strainer plates may dislodge biota that has grown on the plate over time.

5.0 CONCLUSION

Seawater cooling overboard discharge has a potential to cause an adverse environmental effect because:

1) Nitrogen, copper, nickel, and silver concentrations in the discharge exceed Federal and the most stringent state water quality criteria, and the mass loadings of nitrogen, copper, nickel, and silver are significant; and

2) Some vessels could exceed some states' thermal mixing zone requirements while in port.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. System engineering information was used to estimate the rate of discharge. Table 7 shows the sources of data used to develop this NOD report.

Specific References

1. UNDS Equipment Expert Meeting Minutes. Seawater Cooling Water Overboard . 27 August 1996.

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3. Tsao, Fred, NAVSEA 03L32. Sea Strainer Blowdown, 21 December 1996, Clarkson Meredith, Versar, Inc.

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5. NAVSEA. Thermal Effects Screening of Discharges from Vessels of the Armed Services. Versar, Inc. July 3, 1997.

6. Worris, Matthew, M. Rosenblatt & Son, Inc. Seawater Cooling Flow Rates, Pierside and Underway, 30 September 1996, Clarkson Meredith, Versar, Inc.

7. Pentagon Ship Movement Data for Years 1991 - 1995, 4 March 1997.

8. UNDS Phase I Sampling Data Report, Volumes 1-13, October 1997.

9. Van der Leeden, et al. The Water Encyclopedia, Second Edition. Lewis Publishers, 1990.

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Virginia. Water Quality Standards. Chapter 260, Virginia Administrative Code (VAC) , 9 VAC 25-260.

Washington. Water Quality Standards for Surface Waters of the State of Washington. Chapter 173-201A, Washington Administrative Code (WAC).

Committee Print Number 95-30 of the Committee on Public Works and Transportation of the House of Representatives, Table 1.

The Water Quality Guidance for the Great Lakes System, Table 6A. Volume 60 Federal Register, p. 15366. 23 March 1995.

UNDS Ship Database, August 1, 1997.

Table 1. Typical Ship Movement Data

Vessel Class	Quantity	Number of Transits/Vessel/Year	Hours per Transit	Days in Port/Vessel/Year	Days Operating within 12 n.m.
Surface Ships, Submarines					
Forrestal Class Aircraft Carriers CV 59	1	6	4	143	0
Kitty Hawk Class Aircraft Carriers CV 63	3	7	4	137	0
Enterprise Class Aircraft Carriers CVN 65	1	6	4	76	0
Nimitz Class Aircraft Carriers CVN 68	7	7	4	147	0
Ticonderoga Class Guided Missile Cruisers CG 47	27	12	4	166	0
California Class Guided Missile Cruisers CGN 36	2	11	4	143	0
Virginia Class Guided Missile Cruisers CGN 38	1	11	4	161	0
Spruance Class Destroyers DD 963	31	12	4	178	0
Arleigh Burke Destroyers DDG 51	18	11	4	101	0
Kidd Class Destroyers DDG 993	4	12	4	175	0
Oliver Hazard Perry Guided Missile Frigates FFG 7	43	13	4	167	0
Submarines, SSN, SSBN, All Classes	89	6	4	183	0
Blue Ridge Class Amphibious Command Ships LCC 19	2	8	4	179	0
Wasp Class Amphibious Assault Ships LHD 1	4	13	4	185	0
Tarawa Class Amphibious Assault Ships LHA 1	5	9	4	173	0
Iwo Jima Class Amphibious Assault Ships LPH 2	2	11	4	186	0
Austin Class Amphibious Transport Docks LPD 4	3	11	4	178	0
Amphibious Transport Docks LPD 7	3	12	4	188	0
Amphibious Transport Docks LPD 14	2	11	4	192	0
Anchorage Class Dock Landing Ships LSD 36	5	13	4	215	0
Whidbey Island Class Dock Landing Ships LSD 41	8	13	4	170	0
Harpers Ferry Class Dock Landing Ships LSD 49	3	13	4	215	0
Avenger Class Mine Countermeasures Vessels MCM 1	14	28	4	232	0
Osprey Class Coastal Minehunters MHC 51	12	28	4	232	0
Cyclone Class Coastal Defense Ships PC 1	13	18	4	105	0
Auxiliaries					
Emory S Land Class Submarine Tenders AS 39	3	6	4	293	0
Simon Lake Class Submarine Tender AS 33	1	6	4	229	0
Command Ships AGF	2	12	4	183	0
Jumboised Cimarron Class Oilers AO 177	5	10	4	188	0
Sacramento Class Fast Combat Support Ships AOE 1	4	11	4	183	0

Supply Class Fast Combat Support Ships AOE 6	3	6	4	114	0
Safeguard Class Salvage Ships ARS 50	4	22	4	208	0
Gyre Class Oceanographic Research Ships AGOR 21	1	11	4	113	0
T.G.Thompson Oceanographic Research Ships AGOR 23	2	11	4	113	0
Military Sealift Command					
Kilauea Class Ammunition Ships AE 26	8	4	4	26	0
Mars Class Combat Stores Ships AFS 1	8	7	4	148	0
Missile Range Instrumentation Ships AGM 22	1	4	4	133	0
Mercy Class Hospital Ships AH 19	2	2	4	184	0
Zeus Class Cable Repairing Ships ARC 7	1	2	4	8	0
Mission Class Navigation Research Ships AG 194	2	10	4	151	0
Stalwart Class Ocean Surveillance Ships AGOS 1	5	4	4	70	0
Victorious Class Ocean Surveillance Ships AGOS 19	4	5	4	107	0
Silas Bent & Wilkes Classes Surveying Ships AGS 26	2	6	4	44	0
Waters Class Surveying Ship AGS 45	1	1	4	7	0
John McDonnell Class Surveying Ships AGS 51	2	6	4	96	0
Pathfinder Class Surveying Ships AGS 60	4	6	4	96	0
Algol Class Vehicle Cargo Ships AKR 287	8	3	4	109	0
Maersk Class Fast Sealift Ships AKR 295	3	9	4	59	0
Henry J. Kaiser Class Oilers AO 187	13	6	4	78	0
Potawan Class Fleet Ocean Tugs ATF 166	7	16	4	127	0
US Coast Guard					
High Endurance Cutters WHEC 378	12	13	4	151	0
Medium Endurance Cutters WMEC 213	1	9	4	98	0
Medium Endurance Cutter, WMEC 230	1	11	4	167	0
Medium Endurance Cutters WMEC 210A	5	13	4	235	0
Medium Endurance Cutters WMEC 210B	11	9	4	149	0
Medium Endurance Cutters WMEC 270A	4	6	4	137	0
Medium Endurance Cutters WMEC 270B	9	7	4	164	0
Mackinaw Class Icebreaker WAGB 290	1	4	4	215	146
Polar Class Icebreakers WAGB 399	2	4	4	148	100
Island Class Patrol Craft WPB 110 (A,B & C)	49				
Point Class Patrol Craft WPB 82 (C & D)	36				
Juniper Class Buoy Tenders WLB 225	2	18	4	190	100
Balsam Class Buoy Tenders WLB 180A	8	18	4	190	100
Balsam Class Buoy Tenders WLB 180B	2	5	4	120	200
Balsam Class Buoy Tenders WLB 180C	13	16	4	123	200

Bay Class Icebreaking Tugs WTGB 140	9	1	4	215	146
Inland Buoy Tender WLI 100A	1	0	0	160	201
Inland Buoy Tender WLI 100C	1	0	0	160	201
Inland Buoy Tenders WLI 65303	2	0	0	160	201
Inland Buoy Tenders WLI 65400	2	0	0	160	201
Cosmos Class Inland Construction Tenders WLIC 100	3	0	0	160	201
Anvil Class Inland Construction Tenders WLIC 75A	2	0	0	160	201
Inland Construction Tenders WLIC 75B	3	0	0	160	201
Clamp Class Inland Construction Tenders WLIC 75D	2	0	0	160	201
River Buoy Tender WLR 115	1	0	0	160	201
River Buoy Tenders WLR 75	13	0	0	160	201
River Buoy Tenders WLR 65	6	0	0	160	201
Pamlico Class Inland Construction Tenders WLIC 160	4	0	0	160	201
White Sumac Class Coastal Buoy Tenders WLM 157	9	16	4	123	100
Keeper Class Coastal Buoy Tenders WLM 551	2	16	4	123	200
65 ft. Harbor Tugs WYTL (A, B, C & D)	11				
Army					
Logistics Support Vessel LSV	6	20	4	150	30
Landing Craft Utility LCU-2000	35	3	4	275	60
Large Tug LT-128	6	5	4	245	60
Total	**673**				

Table 2. Seawater Cooling Flow Rates, Examples (Naval Vessels)

Vessel Class	Pierside (gpm)	In Transit (gpm)
Aircraft carriers (CVN 68)	4,100	>170,000
Cruisers (CG 47)	1,650	7,000
Destroyers (DDG 51)	1,500	6,840
Frigates (FFG 7)	1,750	3,000
Amphibious assault ships (LHD 1)	3,000	up to 40,500
Submarines	2,000	10,000 - 12,000

Table 3a. Estimated Annual Flows, Seawater Cooling Water, Navy and MSC

		Estimated Flow Rates (gpm)			Estimated Times within 12 n.m. (hrs)			Estimated Annual Flows (gal)		
	Qty	Pierside	Start-up/ Securing	In Transit	Pierside	Start-up/ Securing	In Transit	Pierside	Start-up/ Securing	In Transit
Surface Ships, Submarines										
Forrestal Class Aircraft Carriers CV 59	1	4,100	170,000	170,000	3,432	288	48	844,272,000	2,937,600,000	489,600,000
Kitty Hawk Class Aircraft Carriers CV 63	3	4,100	170,000	170,000	3,288	336	56	2,426,544,000	10,281,600,000	1,713,600,000
Enterprise Class Aircraft Carriers CVN 65	1	4,100	170,000	170,000	1,824	576	48	448,704,000	5,875,200,000	489,600,000
Nimitz Class Aircraft Carriers CVN 68	7	4,100	170,000	170,000	3,528	672	56	6,075,216,000	47,980,800,000	3,998,400,000
Ticonderoga Class Guided Missile Cruisers CG 47	27	1,650	0	7,000	3,984	0	96	10,649,232,000	0	1,088,640,000
California Class Guided Missile Cruisers CGN 36	2	1,650	7,000	7,000	3,432	1,056	88	679,536,000	887,040,000	73,920,000
Virginia Class Guided Missile Cruisers CGN 38	1	1,650	7,000	7,000	3,864	1,056	88	382,536,000	443,520,000	36,960,000
Spruance Class Destroyers DD 963	31	1,500	0	6,840	4,272	0	96	11,918,880,000	0	1,221,350,400
Arleigh Burke Destroyers DDG 51	18	1,680	0	6,840	2,424	0	88	4,398,105,600	0	650,073,600
Kidd Class Destroyers DDG 993	4	1,500	0	6,840	4,200	0	96	1,512,000,000	0	157,593,600
Oliver Hazard Perry Guided Missile Frigates FFG 7	43	1,750	0	3,000	4,008	0	104	18,096,120,000	0	804,960,000
Submarines, SSN, SSBN, All Classes	89	2,000	11,000	11,000	4,392	576	48	46,906,560,000	33,834,240,000	2,819,520,000
Blue Ridge Class Amphibious Command Ships LCC 19	2	3,000 *	40,500	40,500 *	4,296	384	64	1,546,560,000	1,866,240,000	311,040,000
Wasp Class Amphibious Assault Ships LHD 1	4	3,000	40,500	40,500	4,440	624	104	3,196,800,000	6,065,280,000	1,010,880,000
Tarawa Class Amphibious Assault Ships LHA 1	5	3,000 *	40,500	40,500 *	4,152	432	72	3,736,800,000	5,248,800,000	874,800,000
Iwo Jima Class Amphibious Assault Ships LPH 2	2	3,000 *	40,500	40,500 *	4,464	528	88	1,607,040,000	2,566,080,000	427,680,000
Austin Class Amphibious Transport Docks LPD 4	3	3,000 *	40,500	40,500 *	4,272	528	88	2,306,880,000	3,849,120,000	641,520,000
Amphibious Transport Docks LPD 7	3	3,000 *	40,500	40,500 *	4,512	576	96	2,436,480,000	4,199,040,000	699,840,000
Amphibious Transport Docks LPD 14	2	3,000 *	40,500	40,500 *	4,608	528	88	1,658,880,000	2,566,080,000	427,680,000
Anchorage Class Dock Landing Ships LSD 36	5	3,000 *	40,500	40,500 *	5,160	624	104	4,644,000,000	7,581,600,000	1,263,600,000
Whidbey Island Class Dock Landing Ships LSD 41	8	3,000 *	0	40,500 *	4,080	0	104	5,875,200,000	0	2,021,760,000
Harpers Ferry Class Dock Landing Ships LSD 49	3	3,000 *	0	40,500 *	5,160	0	104	2,786,400,000	0	758,160,000
Avenger Class Mine Countermeasures Vessels MCM 1	14	1,650 *	0	7,000 *	5,568	0	224	7,717,248,000	0	1,317,120,000
Osprey Class Coastal Minehunters MHC 51	12	1,500 *	0	6,840 *	5,568	0	224	6,013,440,000	0	1,103,155,200
Cyclone Class Coastal Defense Ships PC 1	13	200 *	0	1,500 *	2,520	0	144	393,120,000	0	168,480,000
Auxiliaries										
Emory S Land Class Submarine Tenders AS 39	3	2,000 *	40,500	40,500 *	7,032	288	48	2,531,520,000	2,099,520,000	349,920,000
Simon Lake Class Submarine Tender AS 33	1	2,000 *	40,500	40,500 *	5,496	288	48	659,520,000	699,840,000	116,640,000
Command Ships AGF	2	2,000 *	40,500	40,500 *	4,392	576	96	1,054,080,000	2,799,360,000	466,560,000
Jumboised Cimarron Class Oilers AO 177	5	2,000 *	40,500	40,500 *	4,512	480	80	2,707,200,000	5,832,000,000	972,000,000
Sacramento Class Fast Combat Support Ships AOE 1	4	1,650 *	7,500	7,500 *	4,392	528	88	1,739,232,000	950,400,000	158,400,000
Supply Class Fast Combat Support Ships AOE 6	3	1,650 *	0	7,500 *	2,736	0	48	812,592,000	0	64,800,000
Safeguard Class Salvage Ships ARS 50	4	1,500 *	0	6,840 *	4,992	0	176	1,797,120,000	0	288,921,600
Gyre Class Oceanographic Research Ships AGOR 21	1	1,500 *	0	6,840 *	2,712	0	88	244,080,000	0	36,115,200
T.G.Thompson Oceanographic Research Ships AGOR 23	2	1,500 *	0	6,840 *	2,712	0	88	488,160,000	0	72,230,400

Military Sealift Command												
Kilauea Class Ammunition Ships AE 26	8	2,000	*	40,500	40,500	*	624	192	32	599,040,000	3,732,480,000	622,080,000
Mars Class Combat Stores Ships AFS 1	8	2,000	*	40,500	40,500	*	3,552	336	56	3,409,920,000	6,531,840,000	1,088,640,000
Missile Range Instrumentation Ships AGM 22	1	2,000	*	40,500	40,500	*	3,192	192	32	383,040,000	466,560,000	77,760,000
Mercy Class Hospital Ships AH 19	2	2,000	*	40,500	40,500	*	4,416	96	16	1,059,840,000	466,560,000	77,760,000
Zeus Class Cable Repairing Ships ARC 7	1	2,000	*	0	40,500	*	192	0	16	23,040,000	0	38,880,000
Mission Class Navigation Research Ships AG 194	2	1,500	*	6,840	6,840	*	3,624	480	80	652,320,000	393,984,000	65,664,000
Stalwart Class Ocean Surveillance Ships AGOS 1	5	1,500	*	0	6,840	*	1,680	0	32	756,000,000	0	65,664,000
Victorious Class Ocean Surveillance Ships AGOS 19	4	1,500	*	0	6,840	*	2,568	0	40	924,480,000	0	65,664,000
Silas Bent & Wilkes Classes Surveying Ships AGS 26	2	1,500	*	0	6,840	*	1,056	0	48	190,080,000	0	39,398,400
Waters Class Surveying Ship AGS 45	1	1,500	*	0	6,840	*	168	0	8	15,120,000	0	3,283,200
John McDonnell Class Surveying Ships AGS 51	2	1,500	*	0	6,840	*	2,304	0	48	414,720,000	0	39,398,400
Pathfinder Class Surveying Ships AGS 60	4	1,500	*	6,840	6,840	*	2,304	288	48	829,440,000	472,780,800	78,796,800
Algol Class Vehicle Cargo Ships AKR 287	8	2,000	*	0	40,500	*	2,616	0	24	2,511,360,000	0	466,560,000
Maersk Class Fast Sealift Ships AKR 295	3	2,000	*	0	40,500	*	1,416	0	72	509,760,000	0	524,880,000
Henry J. Kaiser Class Oilers AO 187	13	2,000	*	0	40,500	*	1,872	0	48	2,920,320,000	0	1,516,320,000
Potawan Class Fleet Ocean Tugs ATF 166	7	1,650	*	0	7,500	*	3,048	0	128	2,112,264,000	0	403,200,000
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	399									177,600,801,600	160,627,564,800	32,269,468,800

* - These flow rates are estimated based on the mission and the size ship in relation to ships whose flow rates are known.

Seawater Cooling Total: 370,497,835,200

Table 3b. Estimated Annual Flows, Seawater Cooling Water, USCG

		Estimated Flow Rates (gpm)					Estimated Times within 12 n.m. (hrs)			Estimated Annual Flows (gal)		
	Qty	**Pierside**		**Operating within 12 n.m.**	**In Transit**		**Pierside**	**Operating**	**In Transit**	**Pierside**	**Operating within 12 n.m.**	**In Transit**
US Coast Guard												
High Endurance Cutters WHEC 378	12	1,200	*	6,000	6,000	*	3,624	0	104	3,131,136,000	0	449,280,000
Medium Endurance Cutters WMEC 213	1	800	*	4,000	4,000	*	2,352	0	72	112,896,000	0	17,280,000
Medium Endurance Cutter, WMEC 230	1	800	*	4,000	4,000	*	4,008	0	88	192,384,000	0	21,120,000
Medium Endurance Cutters WMEC 210A	5	800	*	4,000	4,000	*	5,640	0	104	1,353,600,000	0	124,800,000
Medium Endurance Cutters WMEC 210B	11	800	*	4,000	4,000	*	3,576	0	72	1,888,128,000	0	190,080,000
Medium Endurance Cutters WMEC 270A	4	800	*	4,000	4,000	*	3,288	0	48	631,296,000	0	46,080,000
Medium Endurance Cutters WMEC 270B	9	800	*	4,000	4,000	*	3,936	0	56	1,700,352,000	0	120,960,000
Mackinaw Class Icebreaker WAGB 290	1	1,000	*	5,000	5,000	*	5,160	3,504	32	309,600,000	490,560,000	9,600,000
Polar Class Icebreakers WAGB 399	2	800	*	4,000	4,000	*	3,552	2,400	32	340,992,000	537,600,000	15,360,000
Island Class Patrol Craft WPB 110 (A,B & C)	49											
Point Class Patrol Craft WPB 82 (C & D)	36											
Juniper Class Buoy Tenders WLB 225	2	800	*	4,000	4,000	*	4,560	2,400	144	437,760,000	537,600,000	69,120,000
Balsam Class Buoy Tenders WLB 180A	8	100	*	500	500	*	4,560	2,400	144	218,880,000	268,800,000	34,560,000
Balsam Class Buoy Tenders WLB 180B	2	100	*	500	500	*	2,880	4,800	40	34,560,000	134,400,000	2,400,000
Balsam Class Buoy Tenders WLB 180C	13	100	*	500	500	*	2,952	4,800	128	230,256,000	873,600,000	49,920,000
Bay Class Icebreaking Tugs WTGB 140	9	100	*	500	500	*	5,160	3,504	8	278,640,000	441,504,000	2,160,000
Inland Buoy Tender WLI 100A	1	50	*	50	50	*	3,840	4,824	0	11,520,000	14,472,000	0
Inland Buoy Tender WLI 100C	1	50	*	50	50	*	3,840	4,824	0	11,520,000	14,472,000	0
Inland Buoy Tenders WLI 65303	2	50	*	50	50	*	3,840	4,824	0	23,040,000	28,944,000	0
Inland Buoy Tenders WLI 65400	2	50	*	50	50	*	3,840	4,824	0	23,040,000	28,944,000	0
Cosmos Class Inland Construction Tenders WLIC 100	3	50	*	50	50	*	3,840	4,824	0	34,560,000	43,416,000	0
Anvil Class Inland Construction Tenders WLIC 75A	2	50	*	250	250	*	3,840	4,824	0	23,040,000	67,536,000	0
Inland Construction Tenders WLIC 75	3	50	*	50	50	*	3,840	4,824	0	34,560,000	43,416,000	0
Clamp Class Inland Construction Tenders WLIC 75D	2	50	*	50	50	*	3,840	4,824	0	23,040,000	28,944,000	0
River Buoy Tender WLR 115	1	50	*	50	50	*	3,840	4,824	0	11,520,000	14,472,000	0
River Buoy Tenders WLR 75	13	50	*	50	50	*	3,840	4,824	0	149,760,000	188,136,000	0
River Buoy Tenders WLR 65	6	50	*	50	50	*	3,840	4,824	0	69,120,000	86,832,000	0
Pamlico Class Inland Construction Tenders WLIC 160	4	100	*	50	50	*	3,840	4,824	0	92,160,000	96,480,000	0
White Sumac Class Coastal Buoy Tenders WLM 157	9	100	*	500	500	*	2,952	2,400	128	159,408,000	302,400,000	34,560,000
Keeper Class Coastal Buoy Tenders WLM 551	2	100	*	500	500	*	2,952	4,800	128	35,424,000	134,400,000	7,680,000
65 ft. Harbor Tugs WYTL (A, B, C & D)	11	50	*	250	250	*	3,840	4,824	0	126,720,000	371,448,000	0
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	227									11,562,192,000	4,376,928,000	1,194,960,000
* - These flow rates are estimated based on the mission and the size ship in relation to ships whose flow rates are known.										**Seawater Cooling Total:**		**17,134,080,000**

Table 3c. Estimated Annual Flows, Seawater Cooling Water, Army

		Estimated Flow Rates (gpm)					Estimated Times within 12 n.m. (hrs)			Estimated Annual Flows (gal)		
	Qty	**Pierside**		**Operating within 12 n.m.**	**In Transit**		**Pierside**	**Operating**	**In Transit**	**Pierside**	**Operating within 12 n.m.**	**In Transit**
Army												
Logistics Support Vessel LSV	6	110		110	110		2,400	320	160	95,040,000	12,672,000	6,336,000
Landing Craft Utility LCU-2000	35	140		140	140		4,400	936	24	1,293,600,000	275,184,000	7,056,000
Large Tug LT-128	6	100	*	100	100	*	3,920	920	40	141,120,000	33,120,000	1,440,000
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	47									1,529,760,000	320,976,000	14,832,000
* - These flow rates are estimated based on the mission and the size ship in relation to ships whose flow rates are known.										**Seawater Cooling Total:**		**1,865,568,000**

Table 4. Summary of Detected Analytes

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Effluent - Influent Log Normal Mean	Mass Loading
	Seawater Cooling Dedicated Influent				Seawater Cooling Dedicated Effluent					
Metals	(µg/L)		(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(µg/L)	(lbs/yr)
Aluminum										
Dissolved	59.7	2 of 5	BDL	207.0	59.84	3 of 5	BDL	175	0.12	390
Total	147.4	4 of 5	BDL	296.0	151.1	4 of 5	BDL	399.0	3.69	11,993
Arsenic										
Dissolved	1.97	2 of 5	BDL	12.60	2.26	1 of 5	BDL	18.50	0.29	943
Total	1.48	1 of 5	BDL	11.30	4.24	3 of 5	BDL	56.60	2.76	8,970
Barium										
Dissolved	15.37	5 of 5	5.80	23.90	18.02	5 of 5	10.10	21.85	2.65	8,613
Total	21.69	5 of 5	15.80	26.60	21.59	5 of 5	15.25	26.50	-0.10	(a)
Boron										
Dissolved	2090	5 of 5	1740	2340	2082	5 of 5	1705	2435	-8.17	(a)
Total	2059	5 of 5	1710	2340	2027	5 of 5	1590	2360	-32.08	(a)
Calcium										
Dissolved	196248	5 of 5	164000	223000	197497	5 of 5	163000	229000	1248.60	4,058,145
Total	195870	5 of 5	164000	220000	192465	5 of 5	155000	218500	-3405.42	(a)
Chromium										
Dissolved	5.47	1 of 5	BDL	10.70	~	0 of 5	BDL	BDL	~	(b)
Total	~	0 of 5	BDL	BDL	7.71	2 of 5	BDL	35.50	7.71	25,059
Copper										
Dissolved	9.86	3 of 5	BDL	18.80	40.55	5 of 5	11.90	1040.00	30.69	99,747
Total	14.88	4 of 5	BDL	27.30	49.37	5 of 5	7.55	1135.00	34.49	112,098
Iron										
Dissolved	11.82	1 of 5	BDL	173.0	12.69	2 of 5	BDL	214	0.87	2,828
Total	227.5	5 of 5	90.6	399.0	241.2	5 of 5	87.65	546.5	13.73	44,625
Lead										
Dissolved	~	0 of 5	BDL	BDL	4.12	1 of 5	BDL	3.40	4.12	13,391
Total	4.19	1 of 5	BDL	2.40	~	0 of 5	BDL	BDL	~	(b)
Magnesium										
Dissolved	617279	5 of 5	485000	741000	620084	5 of 5	470500	758500	2804.72	9,115,777
Total	613048	5 of 5	483000	743000	613252	5 of 5	435500	739000	204.53	664,754
Manganese										
Dissolved	10.58	5 of 5	5.90	24.80	12.44	5 of 5	5.80	26.40	1.86	6,045
Total	18.03	5 of 5	12.20	31.40	19.99	5 of 5	13.35	28.55	1.96	6,370
Molybdenum										
Dissolved	4.31	3 of 5	BDL	7.20	5.89	5 of 5	3.25	11.10	1.58	5,135
Total	3.73	3 of 5	BDL	5.10	3.44	3 of 5	BDL	5.50	-0.29	(a)

Nickel										
Dissolved	~	0 of 5	BDL	BDL	15.4	2 of 5	BDL	96.4	15.39	50,020
Total	~	0 of 5	BDL	BDL	19.6	3 of 5	BDL	95.0	19.55	63,541
Silver										
Total	~	0 of 5	BDL	BDL	2.77	1 of 5	BDL	5.90	2.77	9,003
Sodium										
Dissolved	5065465	5 of 5	3650000	6300000	5248566	5 of 5	4250000	6505000	183101.78	595,109,334
Total	5195468	5 of 5	3810000	6390000	5062513	5 of 5	3730000	6300000	-132954.92	(a)
Thallium										
Dissolved	6.25	1 of 5	BDL	15.30	6.2	1 of 5	BDL	25.0	-0.02	(a)
Total	9.37	2 of 5	BDL	35.60	5.5	1 of 5	BDL	10.8	-3.89	(a)
Tin										
Dissolved	~	0 of 5	BDL	BDL	4.02	2 of 5	BDL	5.50	4.02	13,066
Total	3.44	1 of 5	BDL	4.30	5.19	3 of 5	BDL	35.50	1.75	5,688
Titanium										
Total	4.60	3 of 5	BDL	9.00	5.42	3 of 5	BDL	15.80	0.82	2,665
Vanadium										
Dissolved	5.48	1 of 5	BDL	12.10	5.7	2 of 5	BDL	11.9	0.20	650
Zinc										
Dissolved	18.29	5 of 5	15.80	20.80	30.00	5 of 5	14.15	50.25	11.71	38,059
Total	21.27	5 of 5	13.40	54.80	35.75	5 of 5	11.75	78.40	14.48	47,062
Classicals	(mg/L)		(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	68.5	5 of 5	49.0	84.0	62.8	5 of 5	38.0	94.0	-5.67	(a)
Ammonia as Nitrogen	0.10	3 of 5	BDL	0.22	0.12	4 of 5	BDL	0.24	0.02	65,010
Chemical Oxygen Demand	140.2	5 of 5	70.00	289.0	141.5	4 of 5	BDL	265.0	1.28	4,160,617
Chloride	9270	5 of 5	7600	11000	9641	5 of 5	7750	12900	370.61	1,204,661,245
HEM	~	0 of 5	BDL	BDL	~	0 of 5	BDL	BDL	~	(b)
Nitrate/Nitrite	0.06	4 of 5	BDL	0.45	0.08	4 of 5	BDL	1.71	0.02	65,010
Sulfate	1222	5 of 5	972	1600	1236	5 of 5	930	1440	14.53	47,229,508
Total Dissolved Solids	17618	5 of 5	14800	20700	16966	5 of 5	14300	20500	-651.92	(a)
Total Kjeldahl Nitrogen	0.58	5 of 5	0.20	1.70	0.68	5 of 5	0.34	1.30	0.10	325,048
Total Organic Carbon	1.7	2 of 5	BDL	3.6	2.0	3 of 5	BDL	2.9	0.32	1,040,154

Total Phosphorous	0.08	4 of 5	BDL	0.31	0.07	4 of 5	BDL	0.20	-0.01	(a)
Total Recoverable Oil & Grease	2.1	5 of 5	0.8	12.0	1.29	5 of 5	0.90	2.30	-0.85	(a)
Total Sulfide	4.0	5 of 5	2.0	7.0	5.4	5 of 5	2.0	35.0	1.35	4,388,151
Total Suspended Solids	23.7	5 of 5	20.0	32.0	20.3	5 of 5	10.0	72.0	-3.40	(a)
Volatile Residue	1117	4 of 5	BDL	20700	465	4 of 5	BDL	20600	-652.05	(a)
Organics	(µg/L)		(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(µg/L)	(lbs/yr)
4-Chloro-3-Methylphenol	~	0 of 5	BDL	BDL	6.93	1 of 5	BDL	46.00	6.93	22,524

BDL = Below Detection Limit
~ = Value could not be calculated because samples are BDL
(a) = Mass loading was not determined for parameters for which the influent concentration exceeded the effluent.
(b) = Mass loading was not determined for parameters for which the effluent has a frequency of zero detections.
Log-normal means were calculated using measured analyte concentrations. When a sample set contained one or more samples with the analyte below detection levels (i.e., “non-detect” samples), estimated analyte concentrations equivalent to one-half of the detection levels were also used to calculate the log-normal mean. For example, if a “non-detect” sample was analyzed using a technique with a detection level of 20 mg/L, 10 mg/L was used in the log-normal mean calculation.

Table 5. Estimated Annual Mass Loadings of Constituents

Constituent*	**Log-normal Mean Influent (μg/L)**	**Log-normal Mean Effluent (μg/L)**	**Log-normal Mean Concentration (μg/L)**	**Estimated Annual Mass Loading (lbs/yr)**
Ammonia as Nitrogen	100	120	20	65,010
Nitrate/Nitrite	60	80	20	65,010
Total Kjeldahl Nitrogen	580	680	100	325,048
Total Nitrogen[A]				390,058
Copper				
Dissolved	9.86	40.6	30.7	99,700
Total	14.88	49.37	34.49	112,100
Nickel				
Dissolved	~	15.4	15.4	50,100
Total	~	19.6	19.6	63,700
Silver				
Total	~	2.77	2.77	9,000

* Mass loadings are presented for constituents that exceed ambient WQC and for bioaccumulators only. See Table 4 for a complete listing of mass loadings.
A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 6. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Chronic WQC	Most Stringent State Chronic WQC
Classicals (μg/L)					
Ammonia as Nitrogen	20	BDL	240	None	6 (HI)[A]
Nitrate/Nitrite	80	BDL	1710	None	8 (HI)[A]
Total Kjeldahl Nitrogen	680	340	1300	None	-
Total Nitrogen[B]	760			None	200 (HI)[A]
Metals (μg/L)					
Copper					
Dissolved	40.55	11.90	1040.00	2.4	2.4 (CT, MS)
Total	49.37	7.55	1135.00	2.9	2.9 (FL, GA)
Nickel					
Dissolved	15.4	BDL	96.4	8.2	8.2 (CA, CT)
Total	19.6	BDL	95.0	8.3	7.9 (WA)
Silver					
Total	2.77	BDL	5.90	0.92	1.2 (WA)

Notes:
Refer to federal criteria promulgated by EPA in its National Toxics Rule, 40 CFR 131.36 (57 FR 60848; Dec. 22, 1992 and 60 FR 22230; May 4, 1995)
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CA = California
CT = Connecticut
FL = Florida
GA= Georgia
HI = Hawaii
MS = Mississippi
WA = Washington

Table 7. Data Sources

	Data Source			
NOD Section	**Reported**	**Sampling**	**Estimated**	**Equipment Expert**
2.1 Equipment Description and Operation				X
2.2 Releases to the Environment				X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents	X			X
3.4 Concentrations		X		
4.1 Mass Loadings		X	X	
4.2 Environmental Concentrations		X		
4.3 Thermal Effects			X	
4.4 Potential for Introducing Non-Indigenous Species				X