This document is part of Appendix A, and includes Fire Main Systems: 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)

Fire Main Systems: Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Firemain Systems

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 the firemain discharges 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

Firemain systems distribute seawater for fire fighting and secondary services. The firefighting services are fire hose stations, seawater sprinkling systems, and foam proportioning stations. Fire hose stations are distributed throughout the ship. Seawater sprinkling systems are provided for spaces such as ammunition magazines, missile magazines, aviation tire storerooms, lubricating oil storerooms, dry cargo storerooms, living spaces, solid waste processing rooms, and incinerator rooms. Foam proportioning stations are located in rough proximity to the areas they protect, but are separated from each other for survivability reasons. Foam proportioners inject fire fighting foam into the seawater, and the solution is then distributed to areas where there is a risk of flammable liquid spills or fire. Foam discharge is covered in the aqueous film forming foam (AFFF) NOD report. The secondary services provided by wet firemain systems are washdown countermeasures, cooling water for auxiliary machinery, eductors, ship stabilization and ballast tank filling, and flushing for urinals, commodes and pulpers. The washdown countermeasure system includes an extensive network of pipes and nozzles, to produce a running water film on exterior ship surfaces. Not all these services are provided on all vessels.

Firemain systems fall under two major categories: wet and dry firemains. Wet firemains are continuously pressurized so that the system will provide water immediately upon demand. Dry firemains are not charged with water and, as a result, do not supply water upon demand. Most vessels in the Navy's surface fleet operate wet firemains.[1] Most vessels in the Military Sealift Command (MSC) use dry firemains.[1] All U.S. Coast Guard (USCG), and U.S. Army vessels use dry firemains.

For the purposes of the Firemain Systems NOD report, the firemain system includes all components between the fire pump suction sea chest and the cutout valves to the various services. If the discharge from the service is not covered by its own NOD report, it is included in this Firemain Systems NOD report. The components of the firemain system are the sea chests, fire pumps, valves, piping, fire hose, and heat exchangers.

Seawater from the firemain is discharged over the side from fire hoses, or directly to the sea through submerged pipe outlets. Seawater discharges from secondary services supplied from the firemain are described in the pertinent NOD reports; see Section 2.2 below.

The sea chest is a chamber inset into the hull, from which seawater flows to a fire pump. The fire pump sea chests are constructed of the hull material - steel - and are coated with durable epoxy paints. They also contain steel waster pieces or zinc sacrificial anodes for corrosion protection. The fire pumps are constructed of titanium, stainless steel, copper alloyed with tin or nickel, or non-metallic composites. The pipes in wet firemain systems are primarily copper-nickel alloys and fittings are bronze that are connected by welding or by silver-brazed joints. Dry firemain systems can be constructed of these same materials but are normally constructed of steel.

Fire pumps are centrifugal style pumps driven by steam turbines, electric motors, and/or diesel engines. The pumps are located in the lower levels of vessels and are sized to deliver required flow and pressure to equipment or systems on the upper decks. Pump sizes range from 50 to 250 gallons per minute (gpm) on small vessels to 2,000 gpm on large vessels.[1] To prevent overheating when firemain load demands are low, Navy fire pumps are designed to pass 3 to 5% of the nominal flow rate back to the sea suction or overboard.[2] This also provides flow to the pump's seals.

The firemain piping layout (architecture) is governed by the mission or combatant status of the ship. The simplest architecture consists of a single main run fore and aft in the ship, with single branches to the various services supplied from the firemain. More complex architectures incorporate multiple, widely separated mains with cross connects, and feature multiple pipe paths to vital services. Regardless of the architecture, all firemain systems include pipe sections which may contain stagnant water. For example, except during fire fighting, the valves at the fire plugs are closed and sprinkling systems do not flow.

Navy firemain system capacity is designed to meet peak demand during emergency conditions, after sustaining damage. This capacity is determined by adding the largest fire fighting demand, the vital continuous flow demands, and a percentage of the intermittent cooling demands. The number of fire pumps required to meet this capacity is increased by a 33% margin to account for battle damage or equipment failure.[2] As a result, Navy firemain systems have excess capacity during routine operations.

Firemain capacity on most MSC, U.S. Coast Guard (USCG), and Army ships is designed to commercial standards as prescribed by regulations pertinent to each ship type.[3,4] Ships acquired from naval or other sources satisfy other design criteria, but the firemain capacity requirements meet or exceed commercial standards. A minimum of two pumps is required. The required firemain capacity is less than would be required on Navy ships of similar type and size.

Dry firemains are not charged and do not provide instantaneous water pressure. These systems are periodically tested as part of the planned maintenance system (PMS) and are pressurized during training exercises.

2.2 Releases to the Environment

Seawater discharged overboard from the firemain contains entrained or dissolved materials, principally metals, from the components of the firemain system. Some traces of oil or other lubricants may enter the seawater from valves or pumps.

Fire fighting, space dewatering using eductors, counterflooding, and countermeasure washdown constitute emergency discharges from the firemain, and are not incidental to the vessel's operation. Some auxiliary machinery is provided with backup emergency cooling from the firemain. Use of the firemain for backup emergency cooling is not an incidental discharge. Seawater from the firemain is released to the environment as an incidental discharge for the following services:

- Test and maintenance;
- Training;
- Cooling water for auxiliary machinery and equipment, for which the firemain is the normal cooling supply. Examples are central refrigeration plants, steering gear coolers, and the Close In Weapon System;
- Bypass flow overboard from the pump outlet, to prevent overheating of fire pumps when system demands are low; and
- Anchor chain washdown.

The following are incidental services provided from the firemain, but the release to the environment is discussed separately as shown:

- Ballast tank filling (Clean Ballast NOD report);
- Flushing water for commodes (Black Water[sewage]; not part of the UNDS study);
- Flushing water for food garbage grinders (Graywater NOD report);
- Stern tube seals lubrication (Stern Tube Seals & Underwater Bearing Lubrication NOD report); and
- AFFF (AFFF NOD report).

2.3 Vessels Producing the Discharge

All Navy surface ships use wet firemain systems with the exception of two classes of oceanographic research ships. Submarines use dry systems. Boats and craft are not equipped with firemain systems and generally use portable fire pumps or fire extinguishers for fire fighting. Most ships operated by the MSC use dry firemain systems, so they do not continuously discharge water overboard as part of normal operations; however, two classes of ships use wet firemains. These classes are ammunition ships (T-AE) and combat stores ships (T-AFS). The USCG and Army use dry firemain systems, so they do not continuously discharge water overboard as part of normal operations. Table 1 lists the ships and submarines in the Navy, MSC, USCG, and Army, and notes whether their firemain systems are the wet or dry type.

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

Firemain discharge occurs both within and beyond 12 nautical miles (n.m.) of shore.

3.2 Rate

The flow rates for wet firemain discharge depend on the type, number, and operating time of equipment and systems that use water from the firemain. Operating times of many systems are highly variable. Some connected services, such as refrigeration plants, are operated continuously; others, such as hydraulics cooling or aircraft carrier jet blast deflectors, are operated only during specific ship evolutions. Ships with auxiliary seawater cooling systems tend to have relatively few services that draw continuous flow from the firemain. For these ships, the firemain discharge will be small compared to the discharge from the seawater cooling system. Table 2 shows the theoretical upper bound estimate of discharge from wet firemain systems, with an estimated total annual volume of approximately 18.6 billion gallons. The estimate is considered an upper bound because, for most ships, all flow from the fire pumps is assumed to be an environmental release attributable to the firemain system.

Sample calculation for Table 2:

(Qty of ships)(Flow rate (gpm))(1440 min/day)(Days within 12 n.m./yr) = gal/yr

The discharge from dry firemains is approximately 0.1% of the discharge from wet firemains because none of the discharge is continuous. A theoretical upper bound estimate for discharges from dry systems within 12 n.m. is given in Table 3.

Sample calculation for Table 3:

(Qty of ships)(Flow rate (gpm))(10 minutes/wk)(Days within 12 n.m./yr)(1 wk/7 days) = gal/yr

The 10 minutes/week is based on a minimum of 2 pumps required by USCG regulations, in addition to a run time of 5 minutes/week per pump based upon equipment expert knowledge.[5,6,7]

3.3 Constituents

The water for firemain services is drawn from the sea and returned to the sea. Metals and other materials from the firemain and its components can be dissolved by the seawater. Table 4 lists such metals and other materials. Where seawater flow is turbulent, particles of metal will be eroded from pump impellers, valve bodies, and pipe sections, and carried in the firemain as entrained particles.[8] Electrochemical corrosion attacks at the junctions of dissimilar metals to produce both dissolved and particulate metals. Any wetted material in the system can contribute dissolved or particulate constituents to the firemain discharge. These constituents can include copper, nickel, aluminum, tin, silver, iron, titanium, chromium, and zinc. Based on knowledge of the system, the principal expected constituents that are priority pollutants would be copper, nickel, and zinc. Copper and nickel are found in the piping of wet firemain systems, and sacrificial zinc anodes are placed in some sea chests and heat exchangers. None of these expected constituents are bioaccumulators.

Most dry type firemain systems are constructed of steel pipe, without zinc anodes. Therefore, copper, nickel and zinc are not expected constituents of dry type firemain systems.

3.4 Concentrations

The firemain systems of three ships were sampled for 26 metals (total and dissolved), semi-volatile organic compounds, polychlorinated biphenyls (PCBs), and classical constituents. Only wet firemains were sampled because the volumes discharged by wet firemains comprise the vast majority of the total volume of the discharge. The firemains were sampled both at the inlet and at the discharge to determine what constituents were contributed by the firemain system. The three ships sampled were a dock landing ship, an aircraft carrier, and an amphibious assault ship. Details of the sampling effort and the sampled data are described in the Sampling Episodes Report for seawater cooling. Table 4 summarizes the results.

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

Mass loadings are shown in Table 5. The concentrations of constituents contributed by the firemain system were combined with the estimated annual firemain discharge from Table 2 for wet firemains to determine mass loadings by the equation:

Mass Loading (lbs/yr) = (Table 4 net log normal mean concentration (µg/L)) (Table 2 discharge volume (18.6 billion gal/yr))(3.785 L/gal)(2.205 lbs/kg)(10^{-9} kg/µg)

Dry firemains were not sampled. Most dry firemain systems are constructed of steel, so the principal expected metallic constituent will be iron. The discharge rate from dry firemain systems is about 0.1% of the rate from wet firemain systems, so the mass loadings should also be much less. Accordingly, the mass loadings from dry firemain systems were not included in the mass loading estimates.

4.2 Environmental Concentrations

Table 6 compares measured constituent concentrations with Federal and the most stringent state chronic water quality criteria (WQC). The comparison in Table 6 shows that the effluent concentrations of bis(2-ethylhexyl) phthalate, nitrogen (as nitrate/nitrite and total nitrogen), copper, iron, and nickel exceed WQC. The copper and nickel contributions each exceed both the Federal and most stringent state criteria. The ambient copper concentration in most ports exceeds the chronic WQC. As mentioned previously, copper and nickel constitute the major construction materials for wet firemains in the Navy. Bis(2-ethylhexyl) phthalate, nitrogen, and iron concentration exceeds the most stringent state chronic criterion.

4.3 Thermal Effects

As mentioned previously, portions of the firemain are used for seawater cooling purposes and will discharge excess thermal energy to receiving waters. The thermal plume from firemains was not modeled directly; however, firemain discharge can be compared to a discharge that was modeled, such as seawater cooling water from an Arleigh Burke Class (DDG 51) guided missile destroyer. The use of DDG51 flow parameters for seawater cooling will overestimate the size of the thermal plume because all vessels have firemain discharge rates less than the estimated pierside seawater cooling rate of 1,680 gpm for a DDG 51 class ship. Additionally, the temperature difference (delta T) between the effluent and influent for firemain is lower (measured at 5°F) than the delta T for seawater cooling from a DDG 51 class ship (measured at 10°F).

The seawater cooling water discharge was modeled using the Cornell Mixing Zone Expert System (CORMIX) to estimate the plume size and temperature gradients in a receiving water body using conditions tending to produce the largest thermal plume. Thermal modeling was performed for the DDG 51 in two harbors (Norfolk, Virginia; and Bremerton, Washington). Of the five states that have the largest presence of Armed Forces vessels, only Virginia, and Washington have established thermal mixing zone criteria.[9] The discharge was also assumed to occur in winter when the discharge would produce the largest thermal plume. Based on modeling for a DDG 51 class ship, the resulting plume did not exceed the thermal mixing zone requirements for Virginia or Washington.[9]

All vessels have firemain discharge rates less than the seawater cooling discharge rate, and delta T's less than the measured temperature difference associated with a DDG 51.

Therefore, the heat rejection rate from any firemain system will be lower than that of a DDG 51 class ship for seawater cooling water. Accordingly, the resulting thermal plume for the firemain discharge is not expected to exceed the thermal criteria for , Virginia or Washington and adverse thermal effects are not anticipated.

4.4 Potential for Introducing Non-Indigenous Species

Wet and dry firemain systems have a minimal potential for transporting non-indigenous species, because the residence times for most portions of the system are short. Some portions of the 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. Anaerobic conditions are not hospitable to most marine organisms. Additionally, firemain systems do not transport large volumes of water over large distances.

5.0 CONCLUSIONS

Firemain discharge has the potential to cause an adverse environmental effect because the concentrations of Bis(2-ethylhexyl) phthalate, nitrogen, copper, nickel, and iron exceed federal or most stringent state water quality criteria and the estimated annual mass loadings for these metals are significant. The thermal effects of this discharge were reviewed and are not significant. The potential for introducing non-indigenous species is minimal.

6.0 REFERENCES

To characterize this discharge, information from various sources was obtained. Process information and assumptions were used to estimate the rate of discharge and sampling was performed to gather results related to the constituents and concentrations of the discharge. Table 7 shows the sources of data used to develop this NOD report.

Specific References

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Malcolm Pirnie, Inc. UNDS Phase 1 Sampling Data Report, Volumes 1 through 13, October 1997.

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. March 23, 1995.

UNDS Ship Database, August 1, 1997.

Table 1. Wet and Dry Firemains of the Navy, MSC, USCG, and Army

Class	Description	Quantity of Vessels	Wet/Dry
	Navy Ships		
SSBN	Ohio Class Ballistic Missile Submarines	17	Dry
SSN	Sturgeon Class Attack Submarines	13	Dry
SSN	Los Angeles Class Attack Submarines	56	Dry
SSN	Narwhal Class Submarine	1	Dry
SSN	Benjamin Franklin Class Submarines	2	Dry
CV	Forrestal Class Aircraft Carrier	1	Wet
CVN	Enterprise Class Aircraft Carrier	1	Wet
CV	Kitty Hawk Class Aircraft Carriers	3	Wet
CVN	Nimitz Class Aircraft Carriers	7	Wet
CGN	Virginia Class Guided Missile Cruiser	1	Wet
CG	Ticonderoga Class Guided Missile Cruisers	27	Wet
CGN	California Class Guided Missile Cruisers	2	Wet
DDG	Kidd Class Guided Missile Destroyers	4	Wet
DDG	Arleigh Burke Class Guided Missile Destroyers	18	Wet
DD	Spruance Class Destroyers	31	Wet
FFG	Oliver Hazard Perry Guided Missile Frigates	43	Wet
LCC	Blue Ridge Class Amphibious Command Ships	2	Wet
LHD	Wasp Class Amphibious Assault Ships	4	Wet
LHA	Tarawa Class Amphibious Assault Ships	5	Wet
LPH	Iwo Jima Class Assault Ships	2	Wet
LPD	Austin Class Amphibious Transport Docks	3	Wet
LPD	Amphibious Transport Docks	2	Wet
LPD	Amphibious Transport Docks	3	Wet
LSD	Whidbey Island Class Dock Landing Ships	8	Wet
LSD	Harpers Ferry Dock Landing Ships	3	Wet
LSD	Anchorage Class Dock Landing Ships	5	Wet
MCM	Avenger Class Mine Countermeasure Vessels	14	Wet
MHC	Osprey Class Minehunter Coastal Vessels	12	Wet
PC	Cyclone Class Coastal Defense Ships	13	Wet
	Navy Auxiliary Ships		
AGF	Raleigh Class Miscellaneous Command Ship	1	Wet
AGF	Austin Class Miscellaneous Command Ship	1	Wet
AO	Jumboised Cimarron Class Oilers	5	Wet
AOE	Supply Class Fast Combat Support Ships	3	Wet
AOE	Sacramento Class Fast Combat Support Ships	4	Wet
ARS	Safeguard Class Salvage Ships	4	Wet
AS	Emory S Land Class Submarine Tenders	3	Wet
AS	Simon Lake Class Submarine Tender	1	Wet
AGOR	Gyre Class Oceanographic Research Ship	1	Dry
AGOR	Thompson Class Oceanographic Research Ships	2	Dry
	Military Sealift Command		
T-AE	Kilauea Class Ammunition Ships	8	Wet
T-AFS	Mars Class Combat Stores Ships	8	Wet
T-ATF	Powhatan Class Fleet Ocean Tugs	7	Dry
T-AO	Henry J Kaiser Class Oilers	13	Dry

Class	Description	Quantity of Vessels	Wet/Dry
T-AGM	Compass Island Class Missile Instrumentation Ships	1	Dry
T-ARC	Zeus Class Cable Repairing Ship	1	Dry
T-AKR	Maersk Class Fast Sealift Ships	3	Dry
T-AKR	Algol Class Vehicle Cargo Ships	8	Dry
T-AGOS	Stalwart Class Ocean Surveillance Ships	5	Dry
T-AGOS	Victorious Class Ocean Surveillance Ships	4	Dry
T-AG	Mission Class Navigation Research Ships	2	Dry
T-AGS	Silas Bent Class Surveying Ships	2	Dry
T-AGS	Waters Class Surveying Ship	1	Dry
T-AGS	McDonnell Class Surveying Ships	2	Dry
T-AGS	Pathfinder Class Surveying Ships	4	Dry
	Coast Guard		
WHEC	Hamilton and Hero Class High Endurance Cutters	12	Dry
WMEC	Storis Class Medium Endurance Cutter	1	Dry
WMEC	Diver Class Medium Endurance Cutter	1	Dry
WMEC	Famous Class Medium Endurance Cutters, Flight A	4	Dry
WMEC	Famous Class Medium Endurance Cutters, Flight B	9	Dry
WMEC	Reliance Class Medium Endurance Cutters, Flight A	5	Dry
WMEC	Reliance Class Medium Endurance Cutters, Flight B	11	Dry
WAGB	Mackinaw Class Icebreaker	1	Dry
WAGB	Polar Class Icebreakers	2	Dry
WTGB	Bay Class Icebreaking Tugs	9	Dry
WPB	Point Class Patrol Craft	36	Dry
WPB	Island Class Patrol Craft	49	Dry
WLB	Juniper Class Seagoing Buoy Tenders	2	Dry
WLB	Balsam Class Seagoing Buoy Tenders, Flight A	8	Dry
WLB	Balsam Class Seagoing Buoy Tenders, Flight B	2	Dry
WLB	Balsam Class Seagoing Buoy Tenders, Flight C	13	Dry
WLM	Keeper Class Coastal Buoy Tenders	2	Dry
WLM	White Sumac Class Coastal Buoy Tenders	9	Dry
WLI	Inland Buoy Tenders	6	Dry
WLR	River Buoy Tenders, 115-foot	1	Dry
WLR	River Buoy Tenders, 75-foot	13	Dry
WLR	River Buoy Tenders, 65-foot	6	Dry
WIX	Eagle Class Sail Training Cutter	1	Dry
WLIC	Inland Construction Tender, 115-foot	1	Dry
WLIC	Pamlico Class Inland Construction Tenders	4	Dry
WLIC	Cosmos Class Inland Construction Tenders	3	Dry
WLIC	Anvil and Clamp Classes Inland Construction Tenders	7	Dry
WYTL	65 ft. Class Harbor Tugs	11	Dry
	Army		
FMS	Floating Machine Shops	3	Dry
LSV	Frank S. Besson Class Logistic Support Vessels	6	Dry
LCU	2000 Class Utility Landing Craft	48	Dry
LT	Inland and Coastal Tugs	25	Dry

Table 2. Theoretical Upper Bound-Estimate of Annual Wet Firemain Discharge

Class	Description	Quantity of Vessels	Flow Rate per Vessel (GPM)	Days w/in 12 n.m.	Estimated Annual Volume for Class, Gal
	Navy				
CV	Forrestal Class Aircraft Carrier	1	1,000	143	205,920,000
CVN	Enterprise Class Aircraft Carrier	1	1,000	76	109,440,000
CV	Kitty Hawk Class Aircraft Carriers	3	1,000	137	591,840,000
CVN	Nimitz Class Aircraft Carriers	7	1,000	147	1,481,760,000
CGN	Virginia Class Guided Missile Cruiser	1	250	166	59,760,000
CG	Ticonderoga Class Guided Missile Cruisers	27	250	161	1,564,920,000
CGN	California Class Guided Missile Cruisers	2	250	143	102,960,000
DDG	Kidd Class Guided Missile Destroyers	4	250	175	252,000,000
DDG	Arleigh Burke Class Guided Missile Destroyers	18	500	101	1,308,960,000
DD	Spruance Class Destroyers	31	250	178	1,986,480,000
FFG	Oliver Hazard Perry Guided Missile Frigates	43	250	167	2,585,160,000
LCC	Blue Ridge Class Amphibious Command Ships	2	400	179	206,208,000
LHD	Wasp Class Amphibious Assault Ships	4	800	185	852,480,000
LHA	Tarawa Class Amphibious Assault Ships	5	800	173	996,480,000
LPH	Iwo Jima Class Assault Ships	2	600	186	321,408,000
LPD	Austin Class Amphibious Transport Docks	3	300	178	230,688,000
LPD	Amphibious Transport Docks	2	300	178	153,792,000
LPD	Amphibious Transport Docks	3	300	178	230,688,000
LSD	Whidbey Island Class Dock Landing Ships	8	300	170	587,520,000
LSD	Harpers Ferry Dock Landing Ships	3	300	215	278,640,000
LSD	Anchorage Class Dock Landing Ships	5	300	215	464,400,000
MCM	Avenger Class Mine Countermeasure Vessels	14	150	232	701,568,000
MHC	Osprey Class Minehunter Coastal Vessels	12	100	232	400,896,000
PC	Cyclone Class Coastal Defense Ships	13	50	50	46,800,000
	Navy Auxiliary				
AGF	Raleigh Class Miscellaneous Command Ship	1	400	183	105,408,000
AGF	Austin Class Miscellaneous Command Ship	1	400	183	105,408,000
AO	Jumboised Cimarron Class Oilers	5	200	188	270,720,000
AOE	Supply Class Fast Combat Support Ships	3	500	114	246,240,000
AOE	Sacramento Class Fast Combat Support Ships	4	600	183	632,448,000
ARS	Safeguard Class Salvage Ships	4	100	202	116,352,000
AS	Emory S Land Class Submarine Tenders	3	400	293	506,304,000
AS	Simon Lake Class Submarine Tender	1	400	229	131,904,000
	Military Sealift Command				
T-AE	Kilauea Class Ammunition Ships	8	300	183	632,448,000
T-AFS	Mars Class Combat Stores Ships	8	300	45	155,520,000
				Total Estimated Annual Volume, (gal):	**18,623,520,000**

Table 3. Theoretical Upper-Bound Estimate of Annual Dry Firemain Discharge

Class	Description	Flow (GPM)	Quantity of Vessels	Days within 12 n.m.	Estimated Annual Volume (gal)
	Navy				
SSBN	Ohio Class Ballistic Missile Submarines	250	17	183	1,111,071
SSN	Sturgeon Class Attack Submarines	250	13	183	849,643
SSN	Los Angeles Class Attack Submarines	250	56	183	3,660,000
SSN	Narwhal Class Submarine	250	1	183	65,357
SSN	Benjamin Franklin Class Submarines	250	2	183	130,714
	Navy Auxiliary				
AGOR	Gyre Class Oceanographic Research Ship	50	1	113	8,071
AGOR	Thompson Class Oceanographic Research Ships	100	2	113	32,286
	Military Sealift Command				
T-ATF	Powhatan Class Fleet Ocean Tugs	100	7	127	127,000
T-AO	Henry J Kaiser Class Oilers	200	13	78	289,714
T-AGM	Compass Island Class Missile Instrumentation Ships	100	2	133	38,000
T-AH	Mercy Class Hospital Ships	400	2	184	210,286
T-ARC	Zeus Class Cable Repairing Ship	100	1	8	1,143
T-AKR	Maesrk Class Fast Sealift Ships	400	3	59	101,143
T-AKR	Algol Class Vehicle Cargo Ships	400	8	350	1,600,000
T-AGOS	Stalwart Class Ocean Surveillance Ships	200	5	70	100,000
T-AGOS	Victorious Class Ocean Surveillance Ship	200	4	107	122,286
T-AG	Mission Class Navigation Research Ships	200	2	151	86,286
T-AGS	Silas Bent Class Surveying Ships	200	2	44	25,143
T-AGS	Waters Class Surveying Ship	200	1	7	2,000
T-AGS	McDonnel Class Surveying Ships	200	2	96	54,857
T-AGS	Pathfinder Class Surveying Ships	200	4	96	109,714
	Coast Guard				
WHEC	Hamilton and Hero Class High Endurance Cutters	250	12	151	647,143
WMEC	Storis Class Medium Endurance Cutter	250	1	167	59,643
WMEC	Diver Class Medium Endurance Cutters	250	1	98	35,000
WMEC	Famous Class Medium Endurance Cutters, Flight A	250	4	137	195,714
WMEC	Famous Class Medium Endurance Cutters, Flight B	250	9	164	527,143
WMEC	Reliance Class Medium Endurance Cutters, Flight A	250	5	235	419,643
WMEC	Reliance Class Medium Endurance Cutters, Flight B	250	11	149	585,357
WAGB	Mackinaw Class Icebreaker	250	1	365	130,357
WAGB	Polar Class Icebreaker	250	2	365	260,714
WTGB	Bay Class Icebreaking Tugs	250	9	365	1,173,214
WPB	Point Class Patrol Craft	50	36	157	403,714
WPB	Island Class Patrol Craft	50	49	157	549,500
WLB	Juniper Class Seagoing Buoy Tenders	200	16	290	1,325,714

Class	Description	Flow (GPM)	Quantity of Vessels	Days within 12 n.m.	Estimated Annual Volume (gal)
WLB	Balsam Class Seagoing Buoy Tenders, Flight A	200	8	290	662,857
WLB	Balsam Class Seagoing Buoy Tenders, Flight B	200	2	220	125,714
WLB	Balsam Class Seagoing Buoy Tenders, Flight C	200	13	223	828,286
WLM	Keeper Class Coastal Buoy Tenders	100	2	323	92,286
WLM	White Sumac Class Coastal Buoy Tenders	100	9	223	286,714
WLI	Inland Buoy Tenders	100	6	365	312,857
WLR	River Buoy Tenders, 115-foot	100	1	365	52,143
WLR	River Buoy Tenders, 75-foot	100	13	365	677,857
WLR	River Buoy Tenders, 65-foot	100	6	365	312,857
WIX	Eagle Class Sail Training Cutter	50	1	188	13,429
WLIC	Inland Construction Tenders, 115 foot	50	1	365	26,071
WLIC	Pamlico Class Inland Construction Tenders	50	4	365	104,286
WLIC	Cosmos Class Inland Construction Tenders	50	3	365	78,214
WLIC	Anvil and Clamp Classes Inland Construction Tenders	50	27	365	703,929
WYTL	65 ft. Class Harbor Tugs	50	14	350	350,000
	Army				
FMS	Floating Machine Shops	400	3	350	600,000
LSV	Frank S. Besson Class Logistic Support Vessel	564	6	180	870,171
LCU	2000 Class Utility Landing Craft	500	48	335	11,485,714
LT	Inland and Coastal Tugs	640	25	295	3,371,429
				Total Estimated Annual Volume, (gal):	**35,992,385**

Note:
1. Estimates assume that all discharge is due to maintenance or testing. All fire fighting exercises are assumed to occur at sea beyond 12 n.m. Maintenance is assumed to occur weekly while vessels are in port, with seawater flowing at the design rate of the pumps for 5 minutes each week.

Table 4: Summary of Detected Analytes Firemain Systems

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 (lbs/yr)
	Seawater Cooling Firemain Influent				Seawater Cooling Firemain Effluent					
Classicals (mg/L)										
ALKALINITY	77.24	3 of 3	72	80	79.12	3 of 3	72	86	1.88	291,179
AMMONIA AS NITROGEN	0.10	2 of 3	BDL	0.18	0.07	1 of 3	BDL	0.11	-0.03	(b)
CHEMICAL OXYGEN DEMAND	132.28	3 of 3	106	179	105.96	2 of 3	BDL	195	-26.32	(b)
CHLORIDE	10497.14	3 of 3	10200	10800	10750.73	3 of 3	9780	12100	253.59	39,276,577
NITRATE/ NITRITE	0.06	2 of 3	BDL	0.34	0.02	1 of 3	BDL	0.4	-0.04	(b)
SULFATE	1273.43	3 of 3	1160	1380	1245.96	3 of 3	1190	1290	-27.47	(b)
TOTAL DISSOLVED SOLIDS-	19705.66	3 of 3	18300	20700	18261.70	3 of 3	16900	19800	-1443.96	(b)
TOTAL KJELDAHL NITROGEN	0.31	2 of 3	BDL	0.95	0.48	3 of 3	0.23	0.84	0.17	26,330
TOTAL ORGANIC CARBON	1.72	2 of 3	BDL	3.2	1.72	2 of 3	BDL	3.2	0	0
TOTAL PHOSPHOROUS	0.15	3 of 3	0.13	0.19	0.15	3 of 3	0.13	0.2	0	0
TOTAL RECOVERABLE OIL AND GREASE	2.79	3 of 3	0.9	5.6	2.16	2 of 3	BDL	10.9	-0.63	(b)
TOTAL SULFIDE (IODOMETRIC)	7.00	2 of 2	BDL	7	6.54	3 of 3	5	8	-0.46	(b)
TOTAL SUSPENDED SOLIDS	21.09	3 of 3	19	26	20.05	3 of 3	12	28	-1.04	(b)
VOLATILE RESIDUE	9016.50	3 of 3	1920	20200	8755.30	3 of 3	2230	19800	-261.2	(b)
Metals (µg/L)										
ALUMINUM										
Dissolved	37.44	1 of 3	BDL	78.1	-	-	-	-	-	-
Total	197.35	2 of 3	BDL	732	85.79	1 of 3	BDL	805.5	-111.56	(b)
ANTIMONY										
Dissolved	7.08	1 of 3	BDL	23.7	-	-	-	-	-	-
ARSENIC										
Dissolved	1.79	1 of 3	BDL	5	2.64	2 of 3	BDL	5	0.85	132
Total	1.27	2 of 3	BDL	3.4	2.71	1 of 3	BDL	5	1.44	223
BARIUM										
Dissolved	20.43	3 of 3	16.5	25.6	18.0	3 of 3	13.4	26.5	-2.39	(b)
Total	21.65	3 of 3	16.1	25.3	23.7	3 of 3	17.7	29.7	2.09	324
BORON										
Dissolved	2109.70	3 of 3	2010	2290	2110	3 of 3	1930	2340	-3.1	(b)
Total	2076.31	3 of 3	2040	2130	2160	3 of 3	2080	2320	80.8	12,514
CALCIUM										
Dissolved	198376.19	3 of 3	190000	214000	195800	3 of 3	179500	219000	-2560.58	(b)
Total	196332.23	3 of 3	187000	213000	198600	3 of 3	186000	217000	2242.88	347,382
COPPER										
Dissolved	8.43	2 of 3	BDL	13.3	24.9	2 of 3	BDL	150	16.46	2,549
Total	16.82	3 of 3	13.1	21.9	62.4	3 of 3	34.2	143	45.59	7,061

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 (lbs/yr)
	Seawater Cooling Firemain Influent				Seawater Cooling Firemain Effluent					
IRON										
Dissolved	-	-	-	-	20.3	1 of 3	BDL	189	20.3 (a)	3,138 (a)
Total	348.48	3 of 3	161	824	370	3 of 3	95.4	910.5	21.28	3,296
MAGNESIUM										
Dissolved	673065.05	3 of 3	634000	697000	657000	3 of 3	590000	698000	-15948.78	(b)
Total	674584.89	3 of 3	664000	689000	672000	3 of 3	663000	678000	-2782.22	(b)
MANGANESE										
Dissolved	11.12	3 of 3	9.4	12.5	10.77	3 of 3	7.4	13.3	-0.35	(b)
Total	17.32	3 of 3	11.4	24.5	19.00	3 of 3	12.2	27.2	1.68	260
MOLYBDENUM										
Dissolved	7.21	2 of 3	BDL	25.5	-	-	-	-	-	-
Total	4.51	1 of 3	BDL	6.1	3.29	1 of 3	BDL	10.8	-1.22	(b)
NICKEL										
Dissolved	-	-	-	-	13.8	1 of 3	BDL	38.9	13.83 (a)	2,142 (a)
Total	-	-	-	-	15.2	1 of 3	BDL	52.1	15.24 (a)	2,360 (a)
SELENIUM										
Dissolved	16.90	1 of 3	BDL	48.3	14.9	1 of 3	BDL	56.7	-1.96	(b)
SODIUM										
Dissolved	5743515.23	3 of 3	5540000	6140000	5710000	3 of 3	5190000	6160000	-37826.6	(b)
Total	5782507.24	3 of 3	5500000	6030000	5780000	3 of 3	5585000	6160000	-37.06	(b)
THALLIUM										
Dissolved	6.80	1 of 3	BDL	12.6	6.52	1 of 3	BDL	11.1	-0.28	(b)
Total	7.15	1 of 3	BDL	14.6	7.27	1 of 3	BDL	15.4	0.12	19
TIN										
Dissolved	7.03	1 of 3	BDL	6.2	-	-	-	-	-	-
TITANIUM										
Total	7.60	2 of 3	BDL	23.7	7.67	2 of 3	BDL	25.8	0.07	11
ZINC										
Dissolved	15.67	2 of 3	BDL	40.5	24.2	3 of 3	21.2	29.5	8.54	1,323
Total	22.76	3 of 3	20	25.1	31.3	3 of 3	21.3	44.9	8.55	1,324
Organics (µg/L)										
BIS(2-ETHYLHEXYL) PHTHALATE	-	-	-	-	22.0	1 of 3	BDL	428	22.04 (a)	3,414 (a)

BDL= Below Detection Level

note (a) - No background concentration is given for the parameter - therefore an influent concentration of zero was used to determine a conservative mass loading

note (b) - Mass loading was not determined for parameters for which the influent concentration exceeded the effluent

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 used to calculate the 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)**
Bis(2-ethylhexyl) phthalate	-	22	22.04	3,414
Nitrate/Nitrite	60	20	-40	(a)
Total Kjeldahl Nitrogen	310	480	170	26,330
*Total Nitrogen**				26,330
Copper				
Dissolved	8.43	24.9	16.46	3,111
Total	16.82	62.4	45.59	8,618
Iron				
Total	348.48	370	21.28	4,022
Nickel				
Dissolved	-	13.8	13.8 (b)	2,142 (b)
Total	-	15.2	15.2 (b)	2,360 (b)

* Mass loadings are presented for constituents that exceed WQC only. See Table 4 for a complete listing of mass loadings.

Notes:
* Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.
(a) - Mass loading was not determined for parameters for which the influent concentration exceeded the effluent
(b) - No background concentration is given for the parameter

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)					
Nitrate/Nitrite	20	BDL	400	None	8 (HI)[A]
Total Kjeldahl Nitrogen	480	230	840	None	-
Total Nitrogen[B]	500			None	200 (HI)[A]
Organics (µg/L)					
Bis(2-ethylhexyl) phthalate	22	BDL	428	None	5.92 (GA)
Metals (µg/L)					
Copper					
Dissolved	24.9	BDL	150	2.4	2.4 (CT, MS)
Total	62.4	34.2	143	2.9	2.9 (GA, FL)
Iron					
Total	370	95.4	911	None	300 (FL)
Nickel					
Dissolved	13.8	BDL	38.9	8.2	8.2 (CA, CT)
Total	15.2	BDL	52.1	8.3	7.9 (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.
BDL-Below Detection Level

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

Table 7. Data Sources

	Data Sources			
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	
3.3 Constituents		X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations	X	X		
4.3 Thermal Effects		X	X	
4.4 Potential for Introducing Non-Indigenous Species				X