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

Appendix A

Boiler Blowdown: Nature of Discharge

April 1999

NATURE OF DISCHARGE REPORT

Boiler Blowdown

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 boiler blowdown 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

There are two ways to produce steam for use on ships: conventionally powered boilers and nuclear powered ship steam generators. Conventionally powered boilers and nuclear powered ship steam generators are discussed separately in this report.

2.1.1 Conventionally Powered Ship Boiler Blowdown

Boilers are used to produce steam for the majority of surface vessels that have steam systems. Aboard conventionally powered steam ships, the main propulsion boilers supply steam at high pressure and temperature to the main propulsion turbines, ship service turbogenerators, and a host of auxiliary and hotel services. Many gas turbine and diesel-powered ships have auxiliary or waste heat boilers that produce steam at relatively low pressure for hotel services.

The water supplied to the boiler system (feedwater) is treated to minimize the formation of scale and to inhibit corrosion in the boiler and boiler system piping. All main propulsion boilers in the Navy now use the chelant treatment system, which replaced the coordinated phosphate (COPHOS) treatment system used in main propulsion boilers.[1] Main and auxiliary boilers of the Military Sealift Command (MSC) ships use boiler feedwater chemistry prescribed by the original equipment manufacturer.[2] Auxiliary boilers aboard U.S. Coast Guard (USCG) vessels are treated in accordance with USCG instructions.[3]

The process of boiling water to make steam creates higher concentrations of particulates (the result of corrosion products and sludge forming minerals in the boiler water) and chemicals in the boiler water. The feedwater that is added to maintain the water level in the boiler (boiler water) has a lower concentration of chemicals and dilutes the chemical concentrations that develop during steam generation. Even with careful boiler water treatment management, water or a water/steam mixture must be periodically released from the boiler to remove particulates and sludge and to control boiler water chemical treatment concentrations. This process is referred to as a "boiler blowdown." Blowdowns are accomplished by releasing controlled amounts of boiler water through sea connections that exit the ship below the waterline.

There are four types of boiler blowdown procedures: surface blowdown, scum blowdown, bottom blowdown, and continuous blowdown. Surface blowdowns are used to remove particulates and dissolved materials in the boiler water and to control boiler water chemistry. If contamination or boiler water treatment chemical over-addition exist, both are reduced by a surface blowdown. Scum blowdowns are used to remove surface scum. Bottom blowdowns are used to control the amount of sludge in the boiler water. Continuous blowdowns are used in all chelant treatment systems to rid the boiler of dissolved metal chelates and suspended matter.[1] All boiler blowdowns are performed in accordance with published guidance.

In all cases, except bottom blowdown, blowdowns can be conducted while the boiler is operating. Bottom blowdowns for propulsion and auxiliary boilers are conducted only when the boiler is secured.[1] Waste heat boiler bottom blowdowns can be conducted while the boiler is operating. The four boiler blowdown procedures are conducted in the following ways:

- **Surface blowdowns** discharge approximately five percent of the total volume of water in the boiler.[4,5] During a surface blowdown, the water level in the boiler is increased three to four inches, the surface blowdown valve is opened and then closed when the boiler empties to the normal water level.

- **Scum blowdowns** discharge approximately one percent of the total volume of water in the boiler.[4,5] During a scum blowdown, the water level in the boiler is increased by one inch and the surface blowdown valve is opened and then closed when the boiler empties to the normal water level.[1]

- **Bottom blowdowns** discharge approximately ten percent of the total volume of water in the boiler.[4,5] For a bottom blowdown, the water level in the boiler is increased six inches, the bottom blowdown valve is opened and then closed when the boiler empties to the normal water level.[1]

- **Continuous blowdowns** discharge approximately four percent of the total volume of water in the boiler per day.[5,6] This discharge flows to the bilge of the vessel. Thus, continuous blowdowns are not considered in the total blowdown volume in this report and are covered by the Surface Vessel Bilgewater/OWS Discharge NOD Report.

Ships normally receive steam and electrical power from the pier while they are in port during extended upkeep periods. However, there are occasions when a steam powered ship can have a main propulsion boiler operating in port or at anchor for the operation of a turbogenerator set and to provide hotel service steam. Auxiliary boilers can also be operated in port to provide hotel service steam. When a boiler is secured in port (laid-up), one of six different methods is used. Only one of these methods, placing the boiler under a steam blanket, results in boiler blowdowns. A secured boiler is placed under a steam blanket by keeping steam continuously applied to the boiler. This steam can be from shore or from an operating boiler on the ship. The steam blanket excludes oxygen, thereby minimizing the potential for corrosion in the boiler. Boilers under a steam blanket require a blowdown because the steam applied to the boiler condenses and increases the boiler's water level. A blowdown returns the water to its proper level.

2.1.1.1 Chelant Feedwater Treatment

The chelant system adds ethylenediaminetetraacetic acid (EDTA) to the boiler feedwater in powder form. Only distilled water is used as feedwater in the system. EDTA reacts with metal ions and forms soluble metal chelates (that do not precipitate) that are removed during blowdowns.[7] This helps reduce boiler scaling by removing calcium and magnesium. Hydrazine is used to eliminate residual dissolved oxygen in the feedwater, thus inhibiting the corrosive effects of oxygen in the boiler.

2.1.1.2 Coordinated Phosphate Chemistry

COPHOS systems treat the feedwater to the boiler to reduce boiler scale and corrosion, thus ensuring boiler system reliability. COPHOS systems also use only distilled water as feedwater. Chemicals such as trisodium phosphate, disodium phosphate, and sodium hydroxide are used to precipitate scale forming magnesium and calcium.[1]

Auxiliary and waste heat boilers on Navy ships use a feedwater chemical treatment system similar to COPHOS. This system uses disodium phosphate to reduce boiler corrosion and scale.[1]

2.1.1.3 Drew Ameroid Chemistry

Drew Ameroid systems treat the feedwater to the boiler with disodium phosphate, sodium hydroxide, and morpholine to control scale and corrosion in the boiler. Main propulsion boilers aboard MSC ships, operating at pressures greater than 850 pounds per square inch (psi), use the Drew Ameroid "Ultra Marine" system of treatment. Main propulsion boilers aboard MSC ships, operating at pressures less than 850 psi, use the Drew Standard system. Auxiliary and waste heat boilers on MSC ships use the Drew AKG-100 chemical treatment system.[2] Three different treatment systems are used due to the different operating temperatures of each type of boiler. The treatment chemicals are the same for all three systems but the proportions of the chemicals are different depending on the operating temperature of the boiler.

2.1.1.4 USCG Boiler Water Chemistry

There are no steam-powered ships in the USCG; however, many USCG ships have auxiliary boilers. The preferred method of water treatment in the USCG is a magnetic water treatment (MWT) system, which does not utilize any chemicals. The MWT system uses a device that generates a magnetic field in the water stream to help prevent scale formation. Although the preferred method of treatment is MWT, some USCG ships treat their boiler water with COPHOS, as defined by Navy guidance.[3,8]

2.1.2 Nuclear Powered Ship Steam Generator Blowdown

All nuclear-powered ships have steam generators which require periodic blowdowns (typically about once per week) to maintain safe operation of the system.[4] Section 3 and 4 contain discussions of constituents, concentrations, and mass loadings from nuclear powered ships steam generators, but further information on the process description is classified.

2.1.3 Safety Valve Testing

Testing is necessary to ensure the proper operation of all main and auxiliary boiler safety valves. Safety valves are installed on each boiler to prevent a boiler rupture in the event of excessive pressure buildup. They are installed on the upper portion of the boiler and only discharge steam. Unlike surface and bottom blowdowns, liquid and particulate matter are not discharged from safety valves. Main propulsion boilers usually have three or four safety valves, and auxiliary or waste heat boilers have two valves. Periodic testing results in a very short discharge of steam at full boiler pressure to the atmosphere through an escape pipe on the ship's smokestack. This testing must be performed annually for each boiler. Safety valves must also be tested after each boiler hydrostatic test and whenever a boiler is placed back in service after a repair.[9] For MSC ships, safety valve tests are performed annually during each USCG inspection. These tests are typically performed in port.

Safety valves are tested to measure the exact pressure at which the safety valves fully lift and reset. These pressures are defined by the boiler specifications. If the valves do not lift or reseat at the specified pressure, the test must be repeated after making adjustments to the safety valves until the exact pressures are met.[8] Although steam is discharged at full boiler pressure, the release is to the atmosphere through an escape pipe on the back of the smokestack and only small amounts of condensate reach the water. The discharge is in the form of water vapor released to the atmosphere.

Safety valve testing is also performed on each nuclear powered ship steam generator. This discharge is identical to safety valve testing on conventionally-powered ship boilers; however, the discharge exits below the waterline instead of being released to the atmosphere through an escape pipe. Safety valve testing is performed once every five years on each nuclear steam generator.

2.2 Releases to the Environment

Boiler and steam generator blowdown discharges are infrequent, of short duration (seconds), in small volumes (approximately 310 gallons maximum), and at high pressures (up to 1200 psi). The discharge consists of water and steam or sludge-bearing water at elevated temperatures (above 325° F) and pressures. The discharge can contain metals or boiler water treatment chemicals. The frequency of the discharge is based on boiler and steam generator water chemistry and operation and is therefore not predictable. Boiler and steam generator blowdown discharges are released through hull fittings located below the ship's waterline (underwater discharge).

2.3 Vessels Producing the Discharge

Table 1 list the various Navy, MSC, and USCG vessels which generate boiler blowdown discharge. Ships that use steam for propulsion purposes produce the largest volume of discharge. These ships use high pressure steam (1200 and 600 psi steam systems) to drive propulsion and auxiliary equipment. Diesel and gas turbine powered ships can use fuel fired or waste heat boilers, which operate at pressures up to 150 psi, to generate steam for auxiliary systems. Vessels that use auxiliary and waste heat boilers are also identified in Table 1. All nuclear powered ships have steam generators. There are 89 submarines, 3 nuclear powered cruisers, and 8 nuclear powered aircraft carriers that blow down steam generator water.[4] Army, Marine Corps, and Air Force vessels do not utilize steam systems and do not generate this discharge.

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

Boiler blowdowns can occur when a boiler is operating, after it has been secured, or when under a steam blanket. Thus, these discharges occur within and beyond 12 nautical miles (n.m.) from shore. Safety valve testing on nuclear powered ship steam generators only occurs in port.

3.2 Rate

The volume of water in the boiler while steaming (steaming volume) is used to determine the amount of water/sludge discharged during surface, scum, and bottom blowdowns. These volumes are listed in Table 1 for each ship class and a sample calculation is provided below.[1] Surface blowdowns discharge five percent of the steaming water volume, scum blowdowns discharge one percent of the steaming water volume, and bottom blowdowns discharge ten percent of the steaming water volume.[1] The number of blowdowns per year within 12 n.m. were estimated based on a Naval Ship Systems Engineering Station report on boiler blowdown discharges and revised based on vessel operation within 12 n.m.[5,10] These estimates for each ship category are listed in Table 2. USCG ships with MWT do not use chemical boiler water treatments, but are included in the blowdown table to include their thermal effect and because their blowdown contains metal constituents.[3] USCG ships with COPHOS treated feedwater are also included in the table. The majority of USCG vessel operations are typically performed within 12 n.m. of shore; therefore, the total number of bottom and surface blowdowns is higher than for Navy vessels.[10,11]

Boiler Blowdown Volume, gal per year = (discharge)(number of blowdowns)
Where:
discharge (gal) = (Boiler steaming volume, gal)(percent volume discharged per blowdown)
number of blowdowns = number of blowdowns with 12 n.m. per year

The total blowdown discharge volume within 12 n.m. of shore is 570,860 gallons for Navy main propulsion boilers and 190,348 gallons for Navy auxiliary and waste heat boilers. Total blowdown discharge volume within 12 n.m. is 205,800 gallons for MSC main propulsion boilers and 58,500 gallons for MSC auxiliary and waste heat boilers. The total blowdown discharge volume from USCG auxiliary boilers is 93,600 gallons. The total boiler blowdown discharge volume within 12 n.m. for all Navy, MSC, and USCG ships is 1,119,108 gallons.

Blowdowns for nuclear powered ships steam generators results in a total volume of 3,615,000 gallons per year.[12]

The volume discharged from safety valve testing on nuclear powered ships steam generators is not available. The safety valves are tested once every five years. The available information is in the form of mass loadings and is discussed in Section 4.1.

3.3 Constituents

Boiler blowdown for conventionally powered ships (e.g., steam, diesel, and gas turbine) was sampled under the UNDS sampling program. Samples were taken from five ship classes: the LHD 1 class, the CG 47 class, the LSD 49 class, the T-AO 187 class, and WHEC 378 class. LHD 1 class uses chelant water treatment; CG 47 and LSD 49 classes use COPHOS water treatment; T-AO 187 class uses the Drew Ameroid water treatment; and WHEC 378 uses magnetic water treatment. Boiler samples were analyzed for metals, organics, and classicals based on the boiler blowdown process, system designs, and analytical data available. In addition, hydrazine, a boiler treatment chemical, was specifically tested for since it was not in the aforementioned analyte classes and it was most likely to be present in boiler blowdown. The results of the sampling are provided in Table 3.

The surface blowdown sample for T-AO-187 class was contaminated at the sampling station, which is also used by the ship to sample diesel jacket water (a closed loop cooling system) through common sampling piping.[13] The bottom blowdown sample was taken from the same sampling system, but was completed after the surface blowdown sample was taken and after additional flushing of the piping system had occurred. The constituent concentrations for the bottom blowdown sample appear to be similar to other systems sampled. Even though the surface blowdown constituent concentrations are suspect, they have been used to calculate mass loadings since no other data is available at this time.

The sampling of nuclear powered ships steam generators was conducted separate from the sampling performed on conventionally-powered boilers. Constituent data for nuclear powered ships steam generators is listed in Table 4.[12]

Of the constituents detected in boiler and steam generator blowdown and safety valve testing discharges, antimony, arsenic, cadmium, copper, chromium, lead, nickel, selenium, thallium, zinc, and bis(2-ethylhexyl) phthalate are priority pollutants as defined by the EPA. There are no constituents in boiler or steam generator blowdown that have been identified as bioaccumulators.

3.4 Concentrations

A summary of the analytical results are presented in Table 3.[14] This table shows the constituents, the log-normal mean or concentration value for single sample data, the frequency of detection for each constituent, the minimum and maximum concentrations for multiple sample data, 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 concentrations of constituents in nuclear powered ships steam generator blowdowns are provided in Table 4.[15] No constituent concentration data are available for safety valve testing discharges.

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 1 and 2 and the log-normal mean discharge concentrations, mass loadings are presented in Table 3. Table 5 is present in order to highlight constituents with log-normal mean concentrations that exceed ambient water quality criteria. 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)

$(203\ \mu g/L)(3.785\ L/gal)(590{,}343\ gal/yr)(g/1{,}000{,}000\ \mu g)(lb/453.593\ g) \cong 1\ lb/yr$

The annual mass loadings are reported for the entire fleet. The total annual discharge of copper is only 7.2 pounds per year for conventionally powered ships which is discharged over a large geographical area. The largest metal mass loading discharged is iron at 37.5 pounds per year for conventionally powered boilers which is discharged over a large geographical area. These loadings include the constituent concentration data from the T-AO 203 surface blowdown sample even though this sample has been determined to be contaminated.

The annual mass loadings per ship class are reported for the ship classes that the samples were taken. The total loading of copper for the LHD 1 class (Chelant) is 0.063 pounds, for the CG 47 and LSD 49 classes (COPHOS) is 1.6 pounds, for the WHEC 378 class (MWT) is 0.008 pounds, and for the T-AO 187 class (Drew) is 0.194 pounds. A sample calculation of the estimated annual mass loading for copper on the LHD 1 is shown here:

Mass Loading on the LHD 1 for Copper (Total)
= (Surface Blowdown Log-normal Mean Concentration)(Surface Blowdown Flow Rate) +
(Bottom Blowdown Log-normal Mean Concentration)(Bottom Blowdown Flow Rate)
= (203 μg/L)(3.785 L/gal)(32,240 gal/yr)(g/1,000,000 μg)(lb/453.593 g) +
(40.6 μg/L)(3.785 L/gal)(24,800 gal/yr)(g/1,000,000 μg)(lb/453.593 g) ≅ 0.063 lb/yr

Nuclear powered ships steam generator blowdown mass loadings are listed in Table 6. The annual mass loading of copper from nuclear powered ships steam generators is approximately 3.2 pounds per year.

The total annual discharge of copper is only 11.62 pounds for the entire fleet or 0.03 pound per ship per year, which is discharged over a large geographical area. The largest metal discharge is iron at approximately 38.5 pounds annually for the entire fleet or 0.11 pound per ship per year.

Since safety valve testing releases only steam, and not liquid nor particulate matter as in surface and bottom blowdowns, the mass of constituents discharged is expected to be much smaller than that discharged from boiler blowdown. Table 7 lists the discharges from safety valve testing from nuclear powered ships steam generators.[15] The total mass loadings of all constituents for all nuclear powered ships for safety valve testing is approximately 4.38 pounds per year.

4.2 Environmental Concentrations

The constituent concentrations and their corresponding Federal and most stringent state water quality criteria (WQC) are listed in Tables 8 and 9. These tables include the constituent concentrations from the T-AO 203. Federal and most stringent state WQC for metals are based on the dissolved fraction of the metal.

For conventionally powered boilers, copper concentrations for all feedwater treatment systems exceeded Federal and most stringent state WQC. Iron concentrations for all feedwater treatment systems exceeded Florida’s WQC. Lead concentrations for all feedwater treatment systems, except chelant, exceeded Florida’s and Georgia’s WQC but did not exceed the Federal WQC except for Drew Chemicals feedwater treatment. Nickel concentrations for the chelant, Drew Chemicals and COPHOS feedwater treatment systems exceeded Federal and most stringent state WQC. Nickel concentrations for the magnetic water treatment system exceeded the most stringent state (Florida and Georgia) WQC but did not exceed the Federal WQC. Zinc concentrations for the chelant, Drew Chemicals and COPHOS feedwater treatment systems exceeded Federal and most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen) concentrations for all feedwater treatment systems exceeded most stringent state WQC. Phosphorous concentrations for all feedwater treatment systems other than Drew

Chemicals for Bottom Blowdown exceeded most stringent state WQC. Bis(2-Ethylhexyl) phthalate for Drew Chemicals feedwater treatment systems and COPHOS Bottom Blowdown feedwater treatment system exceeded most stringent state WQC.

For nuclear powered ships steam generators, copper concentrations exceed Federal and most stringent state WQC. Lead concentrations exceed Florida's WQC. Nickel concentrations for the CVN 65 carrier exceed both Federal and most stringent state water quality criteria; all other ships are below the Federal WQC for nickel, but are above the most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen) and phosphorous exceed the most stringent state WQC.

Although the concentrations of copper from boiler blowdowns are greater than water quality criteria at the point of discharge, the turbulent mixing, pressure of the blowdown discharge, and small volumes of the blowdown will cause concentrations to decrease rapidly. The estimated discharge velocity at boiler pressure (1200 psi) is 422 ft/sec. This translates to discharge rates of 68 gal/sec for a 2.0 inch diameter discharge fitting and 38.74 gal/sec for a 1.5 inch discharge fitting. As a comparison, at 100 psi (auxiliary boiler pressure) the discharge velocity is 121 ft/sec, which translates to a discharge rate of 11.22 gal/sec from a 1.5 inch diameter discharge fitting. The LHA1 class ships have the boilers that produce the largest volume blowdown of 310 gallons. A bottom blowdown from a boiler on an LHA 1 class ship will only discharge 0.09 grams of copper. Therefore, it is expected concentrations of copper, lead, and nickel will fall below WQC briefly after discharge.

4.3 Thermal Effects

The potential for boiler blowdown to cause thermal environmental effects was evaluated by modeling the thermal plume for boiler blowdown generated under conservative conditions and then comparing the calculated thermal plume to the state thermal plume size requirements. The thermal effects were modeled by using a batch discharge approach which uses thermodynamic equations and geometry to estimate the plume size. The steps to estimate the maximum size of the thermal plume for a given acceptable mixed temperature are given below:[16]

- calculate the total heat and mass injected in a blowdown;
- calculate the volume of water needed to dilute this mass of water such that the acceptable mixed temperature is obtained; and
- use geometry to find the region centered on the release point (and assuming a totally vertically mixed column) that will provide the volume required to reduce the temperature to the desired temperature criteria.

The discharge is directed downward at a high flow rate and at high velocities. Therefore, the plume is assumed to expand outward and equally in all directions, thus forming a vertically cylindrical shape. The velocity of the discharge at the discharge fitting would be 422 ft/sec, which would put the discharge rate at 68 gal/sec from a 2.0 inch diameter discharge fitting and 38.74 gal/sec from a 1.5 inch diameter discharge fitting. As a comparison, at 100 psig (auxiliary boiler pressure), the velocity of the discharge would be 121 ft/sec, which would put the discharge rate at 11.22 gal/sec from a 1.5 inch diameter discharge fitting.

The bottom blowdown discharges from an LHA 1 Class vessel and an AFS 1 Class vessel were modeled. The LHA 1 uses the chelant treatment system and has main propulsion boilers (the largest size) and the AFS 1 uses Drew chemistry with average size boilers. They represent a large boiler blowdown volume and an average boiler blowdown volume. The LHA was modeled with a batch discharge of 310 gallons at roughly 504 °F (262 °C) through a 2-inch diameter pipe at the bottom of the ship. The AFS 1 was modeled with a batch discharge of 150 gallons at 495 °F (257 °C) through a 1.5-inch diameter pipe at the bottom of the ship. A sample calculation is provided at the end of this report. The plume characteristics were compared to thermal mixing zone criteria for Virginia and Washington State, which are the only two states with established thermal plume mixing zone criteria. The Washington State thermal regulations require that when natural conditions exceed 16 °C, no temperature increases will be allowed that will raise the receiving water temperature by greater than 0.3 °C. The mixing zone requirements state that mixing zones shall not extend for a distance greater than 200 feet plus the depth of the water over the discharge point, or shall not occupy greater than 25% of the width of the water body. The Virginia thermal regulations state that any rise above natural temperature shall not exceed 3 °C. Virginia's mixing zone requirements state that the plume shall not constitute more than one-half of the receiving watercourse. They shall not extend downstream at any time a distance more than five times the width of the receiving watercourse at the point of discharge.

The assumptions for all the thermal modeling conducted under the UNDS program are listed below and the results of the thermal modeling for this discharge are summarized in Table 11.[16]

- The discharge will occur during a simulated slack tide event, using a minimum water body velocity (0.03 m/s);
- The discharge would occur during the winter months (largest difference in temperature between the discharge and receiving water temperatures), which results in the largest thermal plume; and
- The average depth of water at the pier is 40 feet.

Using these assumptions, boiler blowdown discharges from all Navy ships meet Virginia and Washington State thermal mixing zone criteria, Table 10.[16]

Safety valve testing from nuclear powered ships steam generators is discharged in small, intermittent bursts of steam that condenses when reaching the water. The volume of water discharged is too small to be effectively modeled and the thermal effects are negligible due to the immediate mixing with surrounding waters.

4.4 Potential for Introducing Non-Indigenous Species

The potential for introducing non-indigenous species is not significant, since the source of the water is treated freshwater that is heated to high temperatures (over 325 °F) and high pressures (up to 1200 psi).

5.0 CONCLUSIONS

5.1 Boiler and Nuclear Powered Ship Steam Generators Blowdowns

Boiler and nuclear powered ships steam generator blowdowns have a low potential to cause an adverse environmental effect because:

- Mass loadings of copper, lead, nickel, bis(2-ethylhexyl) phthalate, ammonia, nitrogen, and phosphorous are small.
- This discharge rapidly dissipates because it occurs at high flow rates (up to 68 gal/sec) and it is a small volume (310 gallons or less). Modeling the discharge plume shows the constituent concentrations and temperature will be below water criteria within a short distance from the ship for all ship classes that discharge boiler blowdown.
- Boiler blowdown is discharged intermittently throughout the U.S. at Armed Forces ports, and each individual port receives only a fraction of the total fleetwide mass loading.

5.2 Safety Valve Testing

Safety valve testing discharge from nuclear powered ships steam generators is released to the water. However, the total mass discharged is small, only 4.38 pounds of all constituents per year for all nuclear powered ships combined. The small volumes of the discharge cause the thermal loading to dissipate in the receiving waters almost immediately after entry. Therefore, safety valve testing has a low potential to cause an adverse environmental effect.

6.0 DATA SOURCES AND REFERENCES

To characterize this discharge, information from various sources was obtained. Sampling data from four surface ships provided concentrations, and mass loadings were calculated from the rate and the concentrations. Table 13 shows the source of data used to develop this NOD report.

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Calculation Sheet # 1
Thermal Batch Discharge Screening Calculations

A. Assumptions and Given Conditions:

1. Saturated liquid heat loss(specific heat, c_p) from 262 °C down to 100 °C emits 0.9 cal/g-°C
2. Water heat loss (specific heat, c_p) from 100 down to regulation temperature (7.44°C Virginia regulation) emits 1 cal/g-°C
3. Heat transfer will occur under conditions of constant pressure
4. Maximum rise in water temperature will be assumed to equal the Virginia regulation of 3°C
5. Ambient temperature is assumed to be 4.44 °C
6. Assume plume will disperse in the shape of a vertical cylinder 4 m in depth
7. Calculations will be based on an LHA 1 blowdown event, therefore:
   - Blowdown discharge temperature is assumed to be 262 °C
   - Blowdown discharge volume is assumed to be 310 gallons

The heat required to change temperature without a phase change is given by the following equation:

$$Q = (m)(c_p)(\Delta T)$$

where: Q = heat (calories)
m = mass of water (grams)
c_p = constant pressure specific heat (cal/g-°C)
ΔT = change in temperature (°C)

B. Determine Mass of Water in Discharge:

Initial volume of water in steam form is 310 gallons of water (LHA 1 Blowdown):

Conversion from gallons of water to mass of water:

$$(8.343 \text{ lbs/gallons})(454 \text{ grams/lbs})(310 \text{ gallons}) = 1.17 \times 10^6 \text{ grams}$$

C) High Temperature Water Heat Loss

$$Q = (m)(c_p)(\Delta T)$$
$$Q = (1.17 \times 10^6 \text{ grams})(0.9 \text{ cal/gram/°C})(262 - 100 \text{ °C})$$
$$Q = 170{,}586{,}000 \text{ calories}$$

D) Water Heat Loss

$$Q = (m)(c_p)(\Delta T)$$
$$Q = (1.17 \times 10^6 \text{ grams})(1 \text{ cal/g-°C})(100 - 7.44 \text{ °C(Virginia regulation)})$$
$$Q = 108{,}295{,}200 \text{ calories}$$

E). Determine Volume of Surrounding Water to Absorb Heat

Calculate the volume of surrounding water required to absorb heat in order to obtain completely mixed water at the regulatory limit (gallons). Assume that the heat lost by the steam and water in the discharge is the same as the heat gained by the surrounding water.

i) Mass of Water Required
Let X= the mass of water required to obtain the mixture, then

$$\Sigma Q = (m)(c_p)(\Delta T)$$
$$(108{,}295{,}200) + (170{,}586{,}000) = (X \text{ grams of water})(1 \text{ cal/g-°C})(3 \text{ °C})$$
$$92{,}960{,}400 \text{ grams} = X$$

Converting to gallons:
(92,960,400 grams)(1 lb/454 grams) (1 gall/8.343lbs) = 24,542 gallons

ii) Total Volume of Water Required to Meet Virginia Regulations = 24,542 gallons + 310 gallons

= **24,850 gallons**

F). Determine Dimensions of Cylinder

The cylinder of water (estimated plume shape) over the water depth to bottom of 4 m (estimated value based on process knowledge):

Volume = 24,850 gallons x 0.0037854 m^3/gallon = 94 m^3

Volume = $(\pi)(d^2/4)(h)$ where d = cylinder diameter and h = cylinder height

Rearranging:

$d^2 = (vol)(4)/(\pi)(h)$

h=4 m (water depth to bottom)
vol=94 m^3

d = **5.5 m (diameter of plume cylinder)**

Table 1. Annual Surface, Scum, and Bottom Blowdown Volumes for each Ship Class of the Navy, MSC, and USCG

Armed Force Owner	Ship Classes with Main Propulsion Boilers	Number of Ships per Class	Number of Boilers per Ship	Boiler Volume During Steaming (gallons per boiler)	Surface Blowdown Volume per year (5% of boiler steaming volume in gallons)	Scum Blowdown Volume per year (1% of boiler steaming volume in gallons)	Bottom Blowdown Volume per year (10% of boiler steaming volume in gallons)	Total Blowdown Volume per year within 12 n.m. (gallons)
Navy	CV 63	3	8	2,200	58,080	10,560	52,800	121,440
	CV 59	1	8	2,000	17,600	3,200	16,000	36,800
	LPH 2	2	2	1,600	7,040	1,280	6,400	14,720
	LPD 7	3	2	1,300	8,580	1,560	7,800	17,940
	LPD 4	3	2	1,200	7,920	1,440	7,200	16,560
	LPD 14	2	2	1,200	5,280	960	4,800	11,040
	LSD 36	5	2	1,600	17,600	3,200	16,000	36,800
	AGF 3	1	2	1,200	2,640	480	2,400	5,520
	AGF 11	1	2	1,300	2,860	520	2,600	5,980
	AO 177	5	2	2,900	31,900	5,800	29,000	66,700
	AOE 1	4	4	1,900	33,440	6,080	30,400	69,920
	AS 33	1	2	1,500	3,300	600	3,000	6,900
	AS 39	3	2	1,400	9,240	1,680	8,400	19,320
	LCC 19	2	2	1,400	6,160	1,120	5,600	12,880
	LHD 1	4	2	3,100	27,280	4,960	24,800	57,040
	LHA 1	5	2	3,100	34,100	6,200	31,000	71,300
Total Boiler Blowdown for Navy Main Propulsion Boilers =570,860								
MSC	T-AE 26	8	3	1,500	39,600	NA	36,000	75,600
	T-AFS 1	8	3	1,500	39,600	NA	36,000	75,600
	T-AGM 22	1	2	1,000	2,200	NA	2,000	4,200
	T-AG 194	2	2	1,000	4,400	NA	4,000	8,400
	T-AH 19	2	2	1,000	4,400	NA	4,000	8,400
	T-AKR 287	8	2	1,000	17,600	NA	16,000	33,600
Total Boiler Blowdown for MSC Main Propulsion Boilers =205,800								

Note: Information obtained from NAVSSES Memo of 23 August, 1991,[5] and M. Rosenblatt & Son, Inc.

Table 1. Annual Surface, Scum, and Bottom Blowdown Volumes for each Ship Class of the Navy, MSC, and USCG

Armed Force Owner	Ship Classes with Auxiliary or Waste Heat Boilers	Number of Ships per Class	Number of Boilers per Ship	Boiler Volume During Steaming (gallons per boiler)	Surface Blowdown Volume per year (5% of boiler steaming volume in gallons)	Scum Blowdown Volume per year (1% of boiler steaming volume in gallons)	Bottom Blowdown Volume per year (10% of boiler steaming volume in gallons)	Total Blowdown Volume per year within 12 n.m. (gallons)
NAVY	DDG 993	4	3	200	6,000	240	4,800	11,040
	CG 47	27	3	100	20,250	810	16,200	37,260
	DD 963	31	3	200	46,500	1,860	37,200	85,560
	AOE 6	3	2	310	4,650	186	3,720	8,556
	LSD 41	8	2	310	12,400	496	9,920	22,816
	LSD 49	3	2	310	4,650	186	3,720	8,556
	ARS 50	4	3	300	9,000	360	7,200	16,560
Total Boiler Blowdown for Navy auxiliary and waste heat boilers =190,348								
MSC	T-AFS 1	8	2	300	6,000	NA	9,600	15,600
	T-ARC 7	1	2	300	750	NA	1,200	1,950
	T-AGS 26	2	2	300	1,500	NA	2,400	3,900
	T-AGS 45	1	2	300	750	NA	1,200	1,950
	T-AGS 51	2	2	300	1,500	NA	2,400	3,900
	T-AGS 60	4	2	300	3,000	NA	4,800	7,800
	T-AO 187	12	2	300	9,000	NA	14,400	23,400
Total Boiler Blowdown for MSC Auxiliary and Waste Heat Boilers =58,500								
USCG	WLIC 160	4	2	100	2,400	NA	2,400	4,800
	WLR 115	1	2	100	600	NA	600	1,200
	WIX 295	1	2	100	600	NA	600	1,200
	WAGB 399*	2	2	100	1,200	NA	1,200	2,400
	WAGB 290*	1	2	100	600	NA	600	1,200
	WHEC 378*	12	2	100	7,200	NA	7,200	14,400
	WMEC 210A	5	2	100	3,000	NA	3,000	6,000
	WMEC 210B	11	2	100	6,600	NA	6,600	13,200
	WLB 180A*	8	2	100	4,800	NA	4,800	9,600
	WLB 180B*	2	2	100	1,200	NA	1,200	2,400
	WLB 180C*	13	2	100	7,800	NA	7,800	15,600
	WLM 157*	9	2	100	5,400	NA	5,400	10,800
	WTGB 140*	9	2	100	5,400	NA	5,400	10,800
Total Boiler Blowdown for Coast Guard Auxiliary Boilers =93,600								
Total Boiler Blowdown for all Ships =1,119,108								

Notes:
Information obtained from NAVSSES Memo of 23 August, 1991,[5] and M. Rosenblatt & Son, Inc.
*=These boilers use magnetic water treatment and do not discharge any chemicals. Their volumes are included because they contribute a thermal load.
NA=USCG Auxiliary boilers do not have surface or scum blow connections and the MSC does not perform scum blowdowns.

Table 2. Estimated Blowdown Frequencies for Calculation of Total Boiler Blowdown Volume within 12 n.m.

Armed Force Owner and Boiler Type	Number of Surface Blowdowns per year per boiler within 12 n.m.	Number of Scum Blowdowns per year per boiler within 12 n.m.	Number of Bottom Blowdowns per year per boiler within 12 n.m.
Navy			
Main Propulsion	22	20	10
Auxiliary and Waste Heat	25	10	20
MSC			
Main Propulsion	22	20	10
Auxiliary and Waste Heat	25	10	20
USCG*			
Auxiliary	60	none	30

Notes:
Information taken from a NAVSSES Memo of 23 August 1991,5 detailing boiler blowdowns per year and revised based ship operation, time in port, and operation within 12 n.m.
* = The USCG auxiliary boilers conduct surface blowdowns once per day.
Most of their activity is performed within 12 n.m. and therefore the number of bottom blowdowns are elevated to control boiler water chemistry.

Table 3. Summary of Detected Analytes

Constituent Chelant Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	38	1 of 1	102
Ammonia As Nitrogen	0.44	1 of 1	1
Biochemical Oxygen Demand	8	1 of 1	21
Chloride	24	1 of 1	64
Nitrate/Nitrite	0.23	1 of 1	1
Sulfate	12	1 of 1	32
Total Dissolved Solids	290	1 of 1	779
Total Kjeldahl Nitrogen	2.5	1 of 1	7
Total Organic Carbon (Toc)	13	1 of 1	35
Total Phosphorous	0.97	1 of 1	3
Total Sulfide (Iodometric)	7	1 of 1	19
Volatile Residue	184	1 of 1	494
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.009	1 of 1	0.03
METALS	(μg/L)		(lbs/yr)
Aluminum			
Dissolved	630	1 of 1	2
Total	494	1 of 1	1
Antimony			
Dissolved	8.3	1 of 1	0.022
Total	9.7	1 of 1	0.026
Arsenic			
Dissolved	1	1 of 1	0.003
Total	2.5	1 of 1	0.007
Barium			
Dissolved	1.7	1 of 1	0.005
Total	2.2	1 of 1	0.006
Boron			
Total	29.6	1 of 1	0.080
Calcium			
Dissolved	51.6	1 of 1	0.1
Total	114	1 of 1	0.3
Cobalt			
Total	10.7	1 of 1	0.03
Copper			
Dissolved	207	1 of 1	1
Total	203	1 of 1	1

Constituent Chelant Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Iron			
Dissolved	626	1 of 1	2
Total	884	1 of 1	2
Magnesium			
Dissolved	179	1 of 1	0.5
Total	195	1 of 1	1
Manganese			
Dissolved	93.5	1 of 1	0.3
Total	95.5	1 of 1	0.3
Molybdenum			
Dissolved	17.6	1 of 1	0.05
Total	18.1	1 of 1	0.05
Nickel			
Dissolved	1,860	1 of 1	5
Total	1,810	1 of 1	5
Sodium			
Dissolved	40,100	1 of 1	108
Total	39,300	1 of 1	106
Zinc			
Dissolved	594	1 of 1	2
Total	601	1 of 1	2
ORGANICS	(µg/L)		(lbs/yr)
Benzoic Acid	1,230	1 of 1	3

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Chelant Bottom Blowdown	**Concentration**	**Frequency of Detection**	**Mass Loading**
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	30	1 of 1	62
Ammonia As Nitrogen	0.11	1 of 1	0.2
Biochemical Oxygen Demand	9	1 of 1	19
Chloride	13	1 of 1	27
Nitrate/Nitrite	0.39	1 of 1	1
Sulfate	7,830	1 of 1	16,183
Total Dissolved Solids	102	1 of 1	211
Total Kjeldahl Nitrogen	0.47	1 of 1	1
Total Organic Carbon (TOC)	12	1 of 1	25
Total Phosphorous	8.4	1 of 1	17
Total Recoverable Oil And Grease	2.45	1 of 1	5
Total Sulfide (Iodometric)	4	1 of 1	8
Volatile Residue	50	1 of 1	103
METALS	(µg/L)		(lbs/yr)
Aluminum			
Dissolved	430	1 of 1	1
Total	477	1 of 1	1
Antimony			
Dissolved	4.5	1 of 1	0.009
Total	5.55	1 of 1	0.011
Arsenic			
Total	1.3	1 of 1	0.003
Barium			
Dissolved	0.75	1 of 1	0.002
Total	0.85	1 of 1	0.002
Calcium			
Total	94.5	1 of 1	0.2
Copper			
Dissolved	75.9	1 of 1	0.2
Total	40.6	1 of 1	0
Iron			
Dissolved	222	1 of 1	0.5
Total	344	1 of 1	1
Manganese			
Dissolved	59.9	1 of 1	0.1
Total	61.3	1 of 1	0.1
Molybdenum			
Dissolved	16	1 of 1	0.03
Total	18.2	1 of 1	0.04

Constituents of Chelant Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Nickel			
Dissolved	1,740	1 of 1	4
Total	1,835	1 of 1	4
Selenium			
Total	6	1 of 1	0.01
Sodium			
Dissolved	37,700	1 of 1	78
Total	38,750	1 of 1	80
Thallium			
Dissolved	1	1 of 1	0.002
Zinc			
Dissolved	377	1 of 1	1
Total	382	1 of 1	1
ORGANICS	(µg/L)		(lbs/yr)
Benzoic Acid	1,385	1 of 1	3

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Magnetic Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	30	1 of 1	8
Ammonia As Nitrogen	0.22	1 of 1	0.1
Biochemical Oxygen Demand	5	1 of 1	1
Chemical Oxygen Demand (COD)	13	1 of 1	4
Chloride	17	1 of 1	5
Nitrate/Nitrite	0.78	1 of 1	0.2
Sulfate	36	1 of 1	10
Total Dissolved Solids	132	1 of 1	37
Total Kjeldahl Nitrogen	1	1 of 1	0.3
Total Organic Carbon (TOC)	6	1 of 1	2
Total Phosphorous	0.05	1 of 1	0.01
Total Recoverable Oil And Grease	1.1	1 of 1	0.3
Total Sulfide (Iodometric)	16	1 of 1	4
Total Suspended Solids	7	1 of 1	2
Volatile Residue	49	1 of 1	14
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.007	1 of 1	0.003
METALS	(µg/L)		(lbs/yr)
Arsenic			
Total	1.3	1 of 1	0.0004
Barium			
Dissolved	41.9	1 of 1	0.01
Total	42.8	1 of 1	0.01
Boron			
Dissolved	38.3	1 of 1	0.01
Total	39.9	1 of 1	0.01
Calcium			
Dissolved	28,900	1 of 1	8
Total	31,300	1 of 1	9
Copper			
Dissolved	15.8	1 of 1	0.004
Total	64.9	1 of 1	0.02
Iron			
Total	4,170	1 of 1	1
Lead			
Dissolved	22.8	1 of 1	0.006
Total	193	1 of 1	0.054

Constituents of Magnetic Surface Blowdown	**Concentration**	**Frequency of Detection**	**Mass Loading**
METALS (Cont'd)	(µg/L)		(lbs/yr)
Magnesium			
Dissolved	1,270	1 of 1	0.4
Total	2,220	1 of 1	1
Manganese			
Total	83	1 of 1	0.02
Nickel			
Total	27.6	1 of 1	0.01
Selenium			
Total	32.4	1 of 1	0.01
Sodium			
Dissolved	8,080	1 of 1	2
Total	5,380	1 of 1	2
Zinc			
Total	53.1	1 of 1	0.01

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Magnetic Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	34	1 of 1	10
Ammonia As Nitrogen	1.4	1 of 1	0.4
Chloride	13	1 of 1	4
Nitrate/Nitrite	0.93	1 of 1	0.3
Sulfate	108	1 of 1	30
Total Dissolved Solids	207	1 of 1	58
Total Organic Carbon (TOC)	3.2	1 of 1	1
Total Phosphorous	0.14	1 of 1	0.04
Total Sulfide (Iodometric)	11	1 of 1	3
Total Suspended Solids	40	1 of 1	11
Volatile Residue	174	1 of 1	49
METALS	(µg/L)		(lbs/yr)
Aluminum			
Total	100	1 of 1	0.03
Arsenic			
Dissolved	1.15	1 of 1	0.0003
Barium			
Dissolved	18.4	1 of 1	0.005
Total	20.2	1 of 1	0.006
Boron			
Total	26.7	1 of 1	0.007
Calcium			
Dissolved	25,750	1 of 1	7
Total	27,400	1 of 1	8
Copper			
Total	63.1	1 of 1	0.02
Iron			
Dissolved	116	1 of 1	0.03
Total	1855	1 of 1	1
Lead			
Dissolved	2.2	1 of 1	0.001
Total	41.7	1 of 1	0.012
Magnesium			
Dissolved	2,455	1 of 1	1
Total	3,000	1 of 1	1
Manganese			
Dissolved	15.3	1 of 1	0.004
Total	40.6	1 of 1	0.01
Nickel			
Total	14.7	1 of 1	0.004
Sodium			
Dissolved	6,385	1 of 1	2
Total	5,140	1 of 1	1
Zinc			
Total	49.9	1 of 1	0.01

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Drew Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	945	1 of 1	1,030
Ammonia As Nitrogen	1.8	1 of 1	2
Chemical Oxygen Demand (COD)	2,030	1 of 1	2,213
Chloride	148	1 of 1	161
Nitrate/Nitrite	115	1 of 1	125
Sulfate	66	1 of 1	72
Total Dissolved Solids	2,540	1 of 1	2,769
Total Kjeldahl Nitrogen	10	1 of 1	11
Total Organic Carbon (TOC)	100	1 of 1	109
Total Phosphorous	0.26	1 of 1	0.3
Total Recoverable Oil And Grease	3.5	1 of 1	4
Total Sulfide (Iodometric)	10	1 of 1	11
Total Suspended Solids	45	1 of 1	49
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.1	1 of 1	0.11
METALS	(µg/L)		(lbs/yr)
Aluminum			
Total	1,140	1 of 1	1
Arsenic			
Dissolved	24.7	1 of 1	0.03
Total	23.5	1 of 1	0.03
Barium			
Dissolved	13.6	1 of 1	0.01
Total	60	1 of 1	0.07
Boron			
Dissolved	177,000	1 of 1	193
Total	175,000	1 of 1	191
Cadmium			
Total	5	1 of 1	0.01
Calcium			
Dissolved	25,400	1 of 1	28
Total	29,900	1 of 1	33
Copper			
Dissolved	14.8	1 of 1	0
Total	2,340	1 of 1	3
Iron			
Dissolved	70.9	1 of 1	0.1
Total	24,800	1 of 1	27

Constituents of Drew Surface Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Lead			
Dissolved	2.9	1 of 1	0.003
Total	463	1 of 1	1
Magnesium			
Dissolved	178	1 of 1	0.2
Total	9,140	1 of 1	10
Manganese			
Total	261	1 of 1	0.3
Molybdenum			
Dissolved	10.6	1 of 1	0.01
Total	10.7	1 of 1	0.01
Nickel			
Total	125	1 of 1	0.1
Sodium			
Dissolved	697,000	1 of 1	760
Total	660,000	1 of 1	720
Tin			
Total	62.4	1 of 1	0.1
Titanium			
Total	28.3	1 of 1	0.03
Zinc			
Dissolved	47.3	1 of 1	0.1
Total	7,850	1 of 1	9
ORGANICS	(µg/L)		(lbs/yr)
2-(Methylthio) Benzothiazole	213	1 of 1	0.2
Bis(2-Ethylhexyl) Phthalate	16	1 of 1	0.02

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of Drew Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
CLASSICALS	(mg/L)		(lbs/yr)
Alkalinity	45	1 of 1	50
Ammonia As Nitrogen	1.5	1 of 1	2
Biochemical Oxygen Demand	8	1 of 1	9
Chloride	49	1 of 1	55
Nitrate/Nitrite	0.32	1 of 1	0.4
Sulfate	4.8	1 of 1	5
Total Dissolved Solids	112	1 of 1	125
Total Kjeldahl Nitrogen	11	1 of 1	12
Total Organic Carbon (TOC)	24	1 of 1	27
Total Recoverable Oil And Grease	2.85	1 of 1	3
Total Sulfide (Iodometric)	10	1 of 1	11
Volatile Residue	81	1 of 1	90
HYDRAZINE	(mg/L)		(lbs/yr)
Hydrazine	0.007	1 of 1	0.01
METALS	(µg/L)		(lbs/yr)
Aluminum			
Dissolved	63.4	1 of 1	0.07
Arsenic			
Dissolved	8.3	1 of 1	0.01
Barium			
Dissolved	15.3	1 of 1	0.02
Total	19.8	1 of 1	0.02
Calcium			
Dissolved	74.3	1 of 1	0.1
Total	83.6	1 of 1	0.1
Copper			
Dissolved	127	1 of 1	0.1
Total	153	1 of 1	0.2
Iron			
Dissolved	44.8	1 of 1	0.05
Total	1,001	1 of 1	1
Lead			
Total	7.35	1 of 1	0.01
Magnesium			
Dissolved	80	1 of 1	0.09
Total	82	1 of 1	0.09

Constituents of Drew Bottom Blowdown	Concentration	Frequency of Detection	Mass Loading
METALS (Cont'd)	(µg/L)		(lbs/yr)
Manganese			
Dissolved	2.95	1 of 1	0.00
Total	21	1 of 1	0.02
Nickel			
Total	12.6	1 of 1	0.01
Selenium			
Total	12.7	1 of 1	0.01
Sodium			
Dissolved	1,590	1 of 1	2
Total	1,425	1 of 1	2
Zinc			
Dissolved	97.8	1 of 1	0.1
Total	277	1 of 1	0.3
ORGANICS	(µg/L)		(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	13	1 of 1	0.01

Table 3. Summary of Detected Analytes (Cont'd)

Constituents of COPHOS Surface Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	97.3	2 of 2	91	104	75
Ammonia As Nitrogen	0.21	2 of 2	0.11	0.39	0.2
Chloride	1.22	1 of 2	BDL	3	1
Hexane Extractable Material	3.87	1 of 2	BDL	6	3
Nitrate/Nitrite	0.45	2 of 2	0.24	0.85	0.3
Sulfate	3.16	1 of 2	BDL	4	2
Total Dissolved Solids	81.0	2 of 2	17	386	62
Total Kjeldahl Nitrogen	0.45	2 of 2	0.28	0.71	0.3
Total Organic Carbon (TOC)	0.87	1 of 2	BDL	1.5	1
Total Phosphorous	11.5	2 of 2	2.6	51	9
Total Recoverable Oil And Grease	8.14	2 of 2	3.4	19.5	6
Total Sulfide (Iodometric)	4.30	1 of 2	BDL	37	3
Total Suspended Solids	11.5	2 of 2	6	22	9
Volatile Residue	67.7	2 of 2	23	199	52
HYDRAZINE	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Hydrazine	0.01	1 of 2	BDL	0.0019	0.01
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Aluminum					
Dissolved	53.7	1 of 2	BDL	103	0.04
Barium					
Total	2.01	1 of 2	BDL	8.1	0.002
Calcium					
Total	36.9	1 of 2	BDL	64.9	0.03
Copper					
Dissolved	103	2 of 2	56.7	187	0.08
Total	3,390	2 of 2	1,310	8,780	3
Iron					
Dissolved	440	2 of 2	334	579	0.3
Total	4,327	2 of 2	2,480	7,550	3
Lead					
Dissolved	2.49	1 of 2	BDL	6.2	0.002
Total	22.4	2 of 2	8.2	61.4	0.017
Magnesium					
Total	91.2	1 of 2	BDL	260	0.070
Manganese					
Dissolved	3.00	2 of 2	1.7	5.3	0.002
Total	85.7	2 of 2	57.8	127	0.066

Constituents of COPHOS Surface Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
METALS (Cont'd)	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Molybdenum					
Dissolved	3.46	1 of 2	BDL	8	0.003
Total	2.68	1 of 2	BDL	4.8	0.002
Nickel					
Dissolved	12.3	1 of 2	BDL	19	0.009
Total	473	2 of 2	253	883	0.4
Sodium					
Dissolved	22,520	2 of 2	6,170	82,200	17
Total	22,505	2 of 2	6,460	78,400	17
Thallium					
Dissolved	0.77	1 of 2	BDL	1.2	0.001
Tin					
Dissolved	3.49	1 of 2	BDL	6.1	0.003
Total	3.69	1 of 2	BDL	6.8	0.003
Titanium					
Total	4.15	1 of 2	BDL	6.9	0.003
Zinc					
Dissolved	26.0	2 of 2	23.4	28.8	0.02
Total	143	2 of 2	67.2	304	0.11

BDL = Below Detection Limit

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 3. Summary of Detected Analytes (Cont'd)

Constituents of COPHOS Bottom Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
CLASSICALS	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Alkalinity	44.5	2 of 2	30	66	36
Ammonia As Nitrogen	0.13	2 of 2	0.12	0.14	0.1
Chloride	1.22	1 of 2	BDL	3	1
Hexane Extractable Material	3.26	1 of 2	BDL	6	3
Nitrate/Nitrite	0.44	2 of 2	0.24	0.81	0.4
Sulfate	4.47	1 of 2	BDL	8	4
Total Dissolved Solids	110	2 of 2	80	150	88
Total Kjeldahl Nitrogen	0.20	1 of 2	BDL	0.8	0.2
Total Organic Carbon (TOC)	1.26	1 of 2	BDL	3.2	1
Total Phosphorous	21.8	2 of 2	15.3	31	17
Total Recoverable Oil And Grease	1.34	2 of 2	0.8	2.25	1
Total Sulfide (Iodometric)	3.08	1 of 2	BDL	19	2
Total Suspended Solids	3.46	1 of 2	BDL	6	3
Volatile Residue	42.0	2 of 2	22	80	34
HYDRAZINE	(mg/L)		(mg/L)	(mg/L)	(lbs/yr)
Hydrazine	0.01	1 of 2	BDL	0.021	0.01
METALS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Aluminum					
Dissolved	58.2	2 of 2	56.6	91.7	0.05
Total	51.8	1 of 2	BDL	95.8	0.04
Antimony					
Dissolved	3.69	1 of 2	BDL	2.3	0.003
Barium					
Total	1.37	2 of 2	0.85	2.2	0.001
Calcium					
Total	73.5	2 of 2	48.9	200	0.06
Copper					
Dissolved	80.0	2 of 2	47.55	135	0.06
Total	1,724	2 of 2	662	4,490	1
Iron					
Total	1430	2 of 2	1210	1690	1
Lead					
Dissolved	2.12	2 of 2	1.5	3	0.002
Total	8.63	2 of 2	4.7	15.9	0.007
Magnesium					
Dissolved	40.4	1 of 2	BDL	70	0.032
Total	57.1	1 of 2	BDL	102	0.046

Constituents of COPHOS Bottom Blowdown	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Mass Loading
METALS (Cont'd)	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Manganese					
Dissolved	2.24	2 of 2	1.7	5.4	0.002
Total	36.1	2 of 2	30.7	42.5	0.029
Molybdenum					
Dissolved	2.81	1 of 2	BDL	5.25	0.002
Total	2.79	1 of 2	BDL	5.2	0.002
Nickel					
Dissolved	15.8	2 of 2	12.95	19.4	0.013
Total	183	2 of 2	119	280	0.1
Sodium					
Dissolved	32,390	2 of 2	19,250	54,500	26
Total	38,737	2 of 2	28,500	52,650	31
Thallium					
Dissolved	0.65	1 of 2	BDL	1.2	0.001
Tin					
Dissolved	2.85	1 of 2	BDL	6.1	0.002
Titanium					
Total	3.61	1 of 2	BDL	7.9	0.003
Zinc					
Dissolved	8.02	1 of 2	BDL	14.3	0.01
Total	58.5	2 of 2	46.9	73	0.05
ORGANICS	(µg/L)		(µg/L)	(µg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	10.8	1 of 2	BDL	42	0.01

BDL = Below Detection Limit

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 4. Maximum Concentration of Constituents Detected in Nuclear Powered Ship Steam Generator Blowdown

Analyte	SSN & SSBN Submarines	CVN 68 Class Carriers	CVN 65 Only
Metals	μg/L	μg/L	μg/L
Aluminum	40	20	20
Antimony	5	U	U
Arsenic	3	20	U
Barium	1	10	U
Cadmium	2	10	10
Calcium	4	70	150
Chromium	2	5	50
Copper	40	150	50
Iron	50	20	80
Lead	10	15	50
Magnesium	1	15	200
Manganese	1	20	20
Molybdenum	20	20	U
Nickel	25	30	90
Silver	1	20	U
Sodium	160,000	160,000	360,000
Tin	2	20	U
Titanium	3	10	U
Zinc	4	10	50
Classicals	mg/L	mg/L	mg/L
Ammonia	0.30	0.30	0.30
Chemical Oxygen Demand	30.00	30.00	30.00
Chloride	0.05	0.05	0.05
Nitrate + Nitrite (as N)	70.00	70.00	70.00
Sulfate	300.00	300.00	300.00
Sulfide	2.00	2.00	2.00
Total Dissolved Solids	1000.00	1000.00	1000.00
Total Kjeldahl Nitrogen	16.00	16.00	16.00
Total Organic Carbon	3.00	3.00	3.00
Total Phosphorous	100.00	100.00	100.00
Total Suspended Solids	2.00	2.00	2.00
Organics	mg/L	mg/L	mg/L
Hydrazine	0.10	0.10	0.10

Note:
U = Analyte analyzed for but not detected

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers

Constituents of Chelant Surface Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.44	1
Nitrate/Nitrite	0.23	1
Total Kjeldahl Nitrogen	2.5	7
Total Nitrogen[A]	2.8	8
Total Phosphorous	0.97	3
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	207	1
Total	203	1
Iron		
Dissolved	626	2
Total	884	2
Nickel		
Dissolved	1,860	5
Total	1,810	5
Zinc		
Dissolved	594	2
Total	601	2

Constituents of Chelant Bottom Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.11	0.2
Nitrate/Nitrite	0.39	1
Total Kjeldahl Nitrogen	0.47	1
Total Nitrogen[A]	0.86	2
Total Phosphorous	8.4	17
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	75.9	0.2
Total	40.6	0
Iron		
Total	344	1
Nickel		
Dissolved	1,740	4
Total	1,835	4
Zinc		
Dissolved	377	1
Total	382	1

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers (Cont'd)

Constituents of Magnetic Surface Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.22	0.1
Nitrate/Nitrite	0.78	0.2
Total Kjeldahl Nitrogen	1	0.3
Total Nitrogen[A]	1.8	0.5
Total Phosphorous	0.05	0.01
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	15.8	0.004
Total	64.9	0.02
Iron		
Total	4170	1
Lead		
Dissolved	22.8	0.006
Total	193	0.054
Nickel		
Total	27.6	0.01

Constituents of Magnetic Bottom Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	1.4	0.4
Nitrate/Nitrite	0.93	0.3
Total Nitrogen[A]	0.93	0.3
Total Phosphorous	0.14	0.04
METALS	(µg/L)	(lbs/yr)
Copper		
Total	63.1	0.02
Iron		
Total	1855	1
Lead		
Total	41.7	0.012
Nickel		
Total	14.7	0.004

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers (Cont'd)

Constituents of Drew Surface Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	1.8	2
Nitrate/Nitrite	115	125
Total Kjeldahl Nitrogen	10	11
Total Nitrogen[A]	125	136
Total Phosphorous	0.26	0.3
METALS		(lbs/yr)
Copper		
Dissolved	14.8	0
Total	2,340	3
Iron		
Total	24,800	27
Lead		
Total	463	1
Nickel		
Total	125	0.1
Zinc		
Total	7,850	9
ORGANICS	(µg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	16	0.02

Constituents of Drew Bottom Blowdown	Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	1.5	2
Nitrate/Nitrite	0.32	0.4
Total Kjeldahl Nitrogen	11	12
Total Nitrogen[A]	11	12
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	127	0.1
Total	153	0.2
Iron		
Total	1,001	1
Lead		
Total	7.35	0.01
Nickel		
Total	12.6	0.01
Zinc		
Dissolved	97.8	0.1
Total	277	0.3
ORGANICS	(µg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	13	0.01

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 5. Estimated Annual Mass Loadings of Constituents for Conventionally Powered Steam Boilers and Auxiliary and Waste Heat Boilers (Cont'd)

Constituents of COPHOS Surface Blowdown	Log Normal Mean Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.21	0.2
Nitrate/Nitrite	0.45	0.3
Total Kjeldahl Nitrogen	0.45	0.3
Total Nitrogen[A]	0.9	0.6
Total Phosphorous	11.5	9
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	103	0.08
Total	3,390	2.60
Iron		
Dissolved	440	0.34
Total	4,327	3.32
Lead		
Total	22.4	0.02
Nickel		
Dissolved	12.3	0.01
Total	472.7	0.36
Zinc		
Total	143	0.11

Constituents of COPHOS Bottom Blowdown	Log Normal Mean Concentration	Estimated Annual Mass Loading
CLASSICALS	(mg/L)	(lbs/yr)
Ammonia as Nitrogen	0.13	0.1
Nitrate/Nitrite	0.44	0.4
Total Kjeldahl Nitrogen	0.2	0.2
Total Nitrogen[A]	0.64	0.6
Total Phosphorous	21.8	17
METALS	(µg/L)	(lbs/yr)
Copper		
Dissolved	80.0	0.06
Total	1,724	1.38
Iron		
Total	1430	1.14
Lead		
Total	8.63	0.01
Nickel		
Dissolved	15.8	0.01
Total	183	0.15
ORGANICS	(µg/L)	(lbs/yr)
Bis(2-Ethylhexyl) Phthalate	10.8	0.01

A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 6. Mass Loadings for Nuclear Powered Ship Steam Generators

Analyte	Discharge Concentration from CVN 65 (µg/L)	Discharge Concentration from CVN 68 (µg/L)	Discharge Concentration from Submarines (µg/L)	Total Loading for 1 CVN 65 per year* (pounds/year)	Total Loading for 7 CVN 68s per year* (pounds/year)	Total Loading for 72 SSNs and 17 SSBNs per year* (pounds/year)	Total Loading From All Steam Generator ships and subs within 12 n.m. (pounds/year)
Copper	50	150	40	0.09	2.72	0.41	3.22
Lead	50	15	10	0.09	0.27	0.10	0.47
Nickel	90	30	25	0.17	0.54	0.25	0.97
Ammonia	30	30	30	0.06	0.54	0.30	0.90
Nitrate/Nitrite	70,000	70,000	70,000	126	1270	710	2106
Total Kjeldahl Nitrogen	16,000	16,000	16,000	28.8	290	162	481
Total Nitrogen[A]	86,000	86,000	86,000	155	1560	872	2587
Total Phosphorous	100,000	100,000	100,000	190	1800	1000	2990

Notes:
* = Loadings are based on total volumes within 12 n.m. including 225,000 gallons per year for CVN 65, 310,000 gallons per year for CVN 68 Class, 16,000 gallons per year each SSN Class vessel, and 4,000 gallons per year for each SSBN Class vessel.
A - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

Table 7. Naval Nuclear Propulsion Summary of Steam Generator Safety Valve Testing Loadings Per Year (maximum values)

Material Discharged	Loading for Submarines and Cruisers (pounds per vessel, per year)	Total Loading for all Submarines and Cruisers (pounds per year)	Total Loading for Carriers (pounds per vessel, per year)	Total Loading for all Carriers (pounds per year)
Phosphorous (as phosphate)	0.003	0.3	0.006 (CVN 65 only)	0.006
Sulfur (as sulfite and sulfate)	0.000	0	0.008 (CVN 65 only)	0.008
Nitrogen (as nitrite or nitrate)	0.001	0.1	0.000	0
Nitrogen (as amines)	0.03	3	0.08	0.64
Hydrazine	0.000	0	0.001	0.008
Organic Acids	0.001	0.1	0.001	0.008
Sodium	0.002	0.2	0.007 (CVN 65 only)	0.007
Total		**3.7**		**0.68**

Note:
Information taken from NAVSEA 08 summary information, May 1997.[15]

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituents of Chelant Surface Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	440	None	6 (HI)[A]
Nitrate/Nitrite	230	None	8 (HI)[A]
Total Kjeldahl Nitrogen	2500	None	-
Total Nitrogen[B]	2800	None	200 (HI)[A]
Total Phosphorous	970	None	25 (HI)[A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	207	2.4	2.4 (CT, MS)
Total	203	2.9	2.5 (WA)
Iron			
Dissolved	626	None	300 (FL)
Total	884	None	300 (FL)
Nickel			
Dissolved	1,860	74	74 (CA, CT)
Total	1,810	74.6	8.3 (FL, GA)
Zinc			
Dissolved	594	90	90 (CA, CT, MS)
Total	601	95.1	84.6 (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 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Chelant Bottom Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	110	None	6 (HI) [A]
Nitrate/Nitrite	390	None	8 (HI)[A]
Total Kjeldahl Nitrogen	470	None	-
Total Nitrogen[B]	860	None	200 (HI)[A]
Total Phosphorous	8400	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	75.9	2.4	2.4 (CT, MS)
Total	40.6	2.9	2.5 (WA)
Iron			
Total	344	None	300 (FL)
Nickel			
Dissolved	1,740	74	74 (CA, CT)
Total	1,835	74.6	8.3 (FL, GA)
Zinc			
Dissolved	377	90	90 (CA, CT, MS)
Total	382	95.1	84.6 (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 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Magnetic Surface Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	220	None	6 (HI) [A]
Nitrate/Nitrite	780	None	8 (HI)[A]
Total Kjeldahl Nitrogen	1000	None	-
Total Nitrogen[B]	1800	None	200 (HI)[A]
Total Phosphorous	50	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	15.8	2.4	2.4 (CT, MS)
Total	64.9	2.9	2.5 (WA)
Iron			
Total	4,170	None	300 (FL)
Lead			
Total	193	217.2	5.6 (FL, GA)
Nickel			
Total	27.6	74.6	8.3 (FL, GA)

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.

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

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Magnetic Bottom Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	1400	None	6 (HI) [A]
Nitrate/Nitrite	780	None	8 (HI)[A]
Total Nitrogen[B]	780	None	200 (HI)[A]
Total Phosphorous	140	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Total	63.1	2.9	2.5 (WA)
Iron			
Total	1855	None	300 (FL)
Lead			
Total	41.7	217.2	5.6 (FL, GA)
Nickel			
Total	14.7	74.6	8.3 (FL, GA)

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.

FL = Florida
GA = Georgia
HI = Hawaii
WA = Washington

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Drew Surface Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	1800	None	6 (HI) [A]
Nitrate/Nitrite	115,000	None	8 (HI)[A]
Total Kjeldahl Nitrogen	10,000	None	-
Total Nitrogen[B]	125,000	None	200 (HI)[A]
Total Phosphorous	260	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	14.8	2.4	2.4 (CT, MS)
Total	2,340	2.9	2.5 (WA)
Iron			
Total	24,800	None	300 (FL)
Lead			
Total	463	217.2	5.6 (FL, GA)
Nickel			
Total	125	74.6	8.3 (FL, GA)
Zinc			
Total	7,850	95.1	84.6 (WA)
ORGANICS	(µg/L)		(µg/L)
Bis(2-Ethylhexyl) Phthalate	16	None	5.92 (GA)

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.

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

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of Drew Bottom Blowdown	Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)		(µg/L)
Ammonia as Nitrogen	1500	None	6 (HI) [A]
Nitrate/Nitrite	320	None	8 (HI)[A]
Total Kjeldahl Nitrogen	11,000	None	-
Total Nitrogen[B]	11,000	None	200 (HI)[A]
METALS	(µg/L)	(µg/L)	(µg/L)
Copper			
Dissolved	127	2.4	2.4 (CT, MS)
Total	153	2.9	2.5 (WA)
Iron			
Total	1,001	None	300 (FL)
Lead			
Total	7.35	217.2	5.6 (FL, GA)
Nickel			
Total	12.6	74.6	8.3 (FL, GA)
Zinc			
Dissolved	97.8	90	90 (CA, CT, MS)
Total	277	95.1	84.6 (WA)
ORGANICS	(µg/L)		(µg/L)
Bis(2-Ethylhexyl) Phthalate	13	None	5.92 (GA)

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.

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

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of COPHOS Surface Blowdown	Log Normal Mean	Minimum Concentration	Maximum Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Ammonia as Nitrogen	210	110	390	None	6 (HI) [A]
Nitrate/Nitrite	450	240	850	None	8 (HI)[A]
Total Kjeldahl Nitrogen	450	280	710	None	-
Total Nitrogen[B]	900			None	200 (HI)[A]
Total Phosphorous	11,500	2600	51,000	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Copper					
Dissolved	103	56.7	187	2.4	2.4 (CT, MS)
Total	3,390	1,310	8,780	2.9	2.5 (WA)
Iron					
Dissolved	440	334	579	None	300 (FL)
Total	4,327	2,480	7,550	None	300 (FL)
Lead					
Total	22.4	8.2	61.4	217.2	5.6 (FL, GA)
Nickel					
Dissolved	12.3	BDL	19	74	74 (CA, CT)
Total	473	253	883	74	8.3 (FL, GA)
Zinc					
Total	143	67.2	304	95.1	84.6 (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
BDL = Below Detection Limit

Table 8. Mean Concentrations of Constituents that Exceed Water Quality Criteria (Cont'd)

Constituents of COPHOS Bottom Blowdown	Log Normal Mean	Minimum Concentration	Maximum Concentration	Federal Acute WQC	Most Stringent State Acute WQC
CLASSICALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Ammonia as Nitrogen	130	120	140	None	6 (HI) [A]
Nitrate/Nitrite	440	240	810	None	8 (HI)[A]
Total Kjeldahl Nitrogen	200	BDL	800	None	-
Total Nitrogen[B]	640			None	200 (HI)[A]
Total Phosphorous	21,800	15,300	31,000	None	25 (HI) [A]
METALS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Copper					
Dissolved	80.0	47.6	135	2.4	2.4 (CT, MS)
Total	1,724	662	4490	2.9	2.5 (WA)
Iron					
Total	1,430	1,210	1,690	None	300 (FL)
Lead					
Total	8.63	4.7	15.9	217.2	5.6 (FL, GA)
Nickel					
Dissolved	15.8	12.95	19.4	74	74 (CA, CT)
Total	183	119	280	74.6	8.3 (FL, GA)
ORGANICS	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Bis(2-Ethylhexyl) Phthalate	10.8	BDL	42	None	5.92 (GA)

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
BDL = Below Detection Limit

Table 9. Concentrations of Constituents that Exceed Water Quality Criteria for Nuclear Powered Steam Generators (maximum values) (μg/L)

Analyte	Discharge Concentration from Submarines	Discharge Concentration from CVN 68 Class carriers	Discharge Concentration from CVN 65 Class carrier	Federal Acute WQC	Most Stringent State Acute WQC
Copper	40	150	50	2.4	2.4 (CT, MS)
Lead	10	15	50	210	5.6 (FL, GA)
Nickel	25	30	90	74	8.3 (FL, GA)
Ammonia	30	30	90	None	6 (HI)[A]
Nitrate/Nitrite	70,000	70,000	70,000	None	8 (HI)[A]
Total Kjeldahl Nitrogen	16,000	16,000	16,000	None	-
Total Nitrogen[B]	86,000	86,000	86,000	None	200 (HI)[A]
Phosphorous	100,000	100,000	100,000	None	25 (HI)[A]

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)
Where historical data were not reported as dissolved or total, the metals concentrations were compared to the most stringent (dissolved or total) state water quality criteria.
A - Nutrient criteria are not specified as acute or chronic values.
B - Total Nitrogen is the sum of Nitrate/Nitrite and Total Kjeldahl Nitrogen.

CT = Connecticut
FL = Florida
GA = Georgia
HI = Hawaii
MS = Mississippi

Table 10. Summary of Thermal Effects of Boiler Blowdown Discharge

Ship Modeled	Discharge Temp (°F)	Discharge Volume (gals)	Ambient Water Temp (°F)	Predicted Plume Width and Length (m)*	Allowable Plume Width (m)	Allowable Plume Length (m)	Predicted Plume Depth (m)
Washington State (0.3°C Δ T)							
LHA 1	503	310	50	19.7	400	73	4
AFS 1	495	150	50	13.4	400	73	4
Virginia (3.0°C Δ T)							
LHA 1	503	310	40	5.5	3,200	32,000	4
AFS 1	495	150	40	3.7	3,200	32,000	4

Note: The discharge was modeled such that the resultant plume is cylindrical shaped, therefore the plume width and length are equal.

Table 11. 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		X
2.3 Vessels Producing the Discharge	UNDS Database			X
3.1 Locality				X
3.2 Rate			X	X
3.3 Constituents		X		
3.4 Concentrations		X		
4.1 Mass Loadings			X	
4.2 Environmental Concentrations		X		
4.3 Thermal Effects			X	
4.4 Potential for Introducing Non-Indigenous Species				X