NATURE OF DISCHARGE REPORT

Distillation and Reverse Osmosis Brine

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 distillation and reverse osmosis (RO) brine discharge and it 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

Distilling and RO plants, known as “water purification plants,” generate freshwater from seawater for a variety of shipboard applications. These include potable water for drinking and hotel services (e.g., sanitary, laundry, and food preparation) and high-purity feedwater for boilers. Vessels with steam turbine propulsion plants are equipped with large boiler systems that require significant amounts of high-purity feedwater for generating high-pressure steam to operate the ship's engines. Vessels also need low-pressure steam for producing hot water and for heating.

2.1.1 Distilling Plants

Distilling plants, also known as evaporators, are used to distill freshwater from seawater. Non-volatile seawater components, such as inorganic and organic solids (dissolved and suspended), remain in the plant and become concentrated. The mixture of concentrated seawater components that remain and the constituents leached from material in the plant is known as brine and is discharged overboard.

There are two types of distilling plants used on Armed Forces vessels. One type uses low-pressure steam as the heat source and generally operates under vacuum. Figure 1 is a diagram of a two-stage flash-type distilling plant. The other type, vapor compression, uses a compressor to "drive" the evaporation process. Both types produce similar brine discharges.

The heat that is essential to the distilling process is transmitted to the influent seawater through one or more heat exchangers. The heat exchangers consist of a series of metal tubes or plates enclosed in a metal casing. They are designed to segregate the heat source fluid (steam in the case of distilling plants) from the fluid to which the heat is transmitted (influent seawater) while providing as much thermal contact through the metal surfaces as possible. This is accomplished by having a high density of tubes or plates.

Condensate, which is segregated from distillate and brine, is produced from the generating steam when it is cooled by distilling plant heat transfer surfaces. The condensate can be directed to a collection tank along with condensate from other heating devices (e.g., ventilation heaters) for reuse in the ship's boilers. The condensate that is not reused in the boilers is a source of non-oily machinery wastewater, as discussed in the NOD report for that discharge.

During the distilling process, inorganic seawater constituents form a scale on the distilling plant heat transfer surfaces. Anti-scaling compounds are continuously injected into the influent seawater to control the scaling. Nevertheless, the surfaces will gradually foul from scaling over extended periods and periodic cleaning is required to restore flow and heat transfer efficiency.

Citric acid cleaning can be done at sea or in port. At-sea acid cleaning is done during distillation by injecting the citric acid solution into the influent seawater. The citric acid reacts with the distilling plant scale to form soluble byproducts that are discharged with the distilling plant brine. Carbon dioxide is also given off by this reaction and is removed by the distilling plant air ejector.

In-port citric acid cleaning is done every 5 to 7 years on Navy distilling plants. The cleaning solution is recirculated between the distilling plant and a tank truck on the pier. The spent cleaning solution is disposed at an off-site shore facility.[1]

2.1.2 RO Plants

RO plants separate freshwater from seawater by using semi-permeable membranes as a physical barrier. The RO membrane retains a large percentage of suspended and dissolved constituents, allowing freshwater to pass through. The retained substances become concentrated into brine. Shipboard RO plants produce lower-purity freshwater than distilling plants, with total dissolved solids (TDS) concentrations two orders of magnitude greater than distilling plant distillate**.**[2]

Because RO plants operate at ambient temperatures, scaling is not a concern. Therefore, chemicals are not used in RO plants for either scaling suppression or cleaning.

2.2 Releases to the Environment

The overboard discharge from water purification plants on vessels is RO and distilling plant brine. The brine primarily consists of seawater, but can also contain materials from the purification plants and anti-scaling treatment chemicals. RO and distilling processes separate a relatively small proportion of freshwater from the influent seawater, returning the slightly more concentrated brine effluent to the sea. The discharged brine from distilling plants is at elevated temperatures, typically 100 to 120 °F.

The citric acid cleaning solutions that are used to periodically clean the distilling plants are either collected on-site after shoreside cleaning or discharged overboard beyond 12 n.m. after at sea cleaning.

2.3 Vessels Producing the Discharge

There are currently 541 vessels of the Armed Forces equipped with water purification plants. Four hundred fifty-seven vessels have distilling plants and the remainder have RO plants. Table 1 provides a list of Navy, MSC, USCG, and Army vessels that produce this discharge.[3]

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

The distilling plant on a steam-propelled vessel can be operated any time the vessel's boilers are operating. MSC steam-propelled ships typically operate one distiller while in port, except for ships on reduced operating status. As a result, discharge of brine from steam-propelled vessels can occur in port, at sea, and while transiting to and from port. However, diesel- and gas-turbine-propelled vessels with distilling plants, and all vessels with RO plants seldom operate their water purification plants in port or while transiting coastal waters less than 12 nautical miles (n.m.) from shore.

For Navy vessels, brine discharge within 12 n.m. is from the production of boiler feedwater. Navy vessels do not produce potable water within 12 n.m., except during extended operations.

3.2 Rate

While the existing Navy fleet has water purification plants of many sizes and capacities, current naval ship design practice is to use standardized water purification plants of two capacities: 12,000-gallons per day (gpd) distilling and RO plants and 100,000-gpd distilling plants. Multiple water purification plants will be used to achieve capacities of up to 450,000-gpd. For example, a destroyer's RO system may include two 12,000-gpd plants, while the new LPD 17 Class amphibious transport dock vessels require five 12,000-gpd plants to meet freshwater demand. Aircraft carriers have multiple 100,000-gpd distilling plants.

The volume of brine discharged from water purification plants depends on the type of plant. When operating, distilling plants are typically run at full capacity, even when the demand for potable water is low. Excess distillate is discharged directly overboard. Based on operating experience, distilling plants generate 17 gallons of brine for every gallon of fresh water. RO plants generate 4 gallons of brine for every gallon of fresh water.[3] These brine production factors can be used to calculate the water purification plant brine flow rate in gallons per day:

Water Purification Plant Brine Flow Rate in gallons per day (gpd) =
(total freshwater flow in gpd) (brine production factor)

A single distilling plant on a typical Navy DD 963 Class destroyer produces 8,000 gpd of freshwater.[4] Therefore:

(8,000 gpd freshwater) (17) = 136,000 gpd brine discharge

A single RO plant on a typical Navy MHC 51 coastal minehunter produces 1,600 gpd of freshwater.[3] Therefore:

(1,600 gpd freshwater) (4) = 6,400 gpd brine discharge

Current Navy vessel water purification plant operating practice is for steam-propelled ships to operate one distilling plant in port for one to five days before departure (to fill boiler feed water tanks) and while transiting through coastal waters less than (<) 12 n.m.). Submarines are normally supplied boiler feed water by shore or a tender while in port. The distilling plants on all these vessels can be operated at full capacity while at sea (greater than (>) 12 n.m.)).

Table 1 shows estimated distilling and RO plant brine discharge quantities for various vessel classes. The estimates are based on available information regarding the number of vessels in each class, type and capacity of water purification plant(s), vessel operating schedules (number of transits and days in port per year), and water purification plant operating practices while in port, in transit (<12 n.m.) and at sea (>12 n.m.). The assumptions and formulas used to calculate the brine discharge estimates are summarized in the notes section of Table 1, and include four hours per vessel transit in coastal waters. The assumptions also include operation of one distilling plant to produce boiler feedwater for four hours prior to departure from port in the case of submarines.[3] Surface steam-powered vessels may operate a distilling plant for as much as three days prior to departure from port (i.e., every second transit).[3,5] The calculation of the total annual brine discharge within 12 n.m. of shore consists of an in-port component and a transit component, which are added together. The formula for a Navy vessel class is:

Annual Flow within 12 n.m. (gals/yr) =
(number of vessels in class) (single distiller brine flow in gal/day/vessel) (number of distillers/vessel) (number of transits/yr) ((3 days before each transit/2 transits) + (4 hours/transit X 1 day/24 hours))

A sample calculation for the LSD 36 Class dock landing ship is as follows:

(5 ships) (510,000 gal/day/ship) (26 transits/yr) ((3 days before each transit /2) + (4/24 day per transit)) = 111 million gals/yr

Table 1 lists the results of the above calculation for all vessels of the Armed Forces. A total of approximately 2.47 billion gallons of distilling and RO plant brine discharges occur annually within 12 n.m. from shore. Of this, approximately 1.84 billion gallons is discharged in port and 620 million gallons is discharged in transit within 12 n.m. These calculations overestimate the actual discharge rate because steam-powered surface ships can operate a distilling plant for less than three days prior to leaving port.

The volume of influent seawater to a distilling plant can be estimated using the ratio of brine produced to gallons of freshwater produced, or 17:1. This ratio indicates that for every 18 gallons of seawater introduced into a distilling plant, 17 gallons of brine is produced. Knowing that a total of approximately 2.47 billion gallons of distilling and RO plant brine discharges occur annually within 12 n.m. of shore, the following calculation can be made to approximate the total annual volume of seawater influent:

(18 gallons of seawater/17 gallons of brine) (2.47 billion gallons of brine)
= 2.62 billion gallons seawater

Therefore, the influent flow rate is approximately 2.62 billion gallons, and the effluent flow rate is approximately 2.47 billion gallons

3.3 Constituents

The three sources of the constituents of water purification plant discharge are: 1) influent seawater; 2) anti-scaling treatment chemicals; and 3) the purification plant components, including heat exchangers, casings, pumps, piping and fittings. The primary constituents of the brine discharge are identical to those in seawater. These include non-volatile dissolved and suspended solids, and metals.

Distilling plants are made primarily of metal alloys that are corroded by seawater, particularly at the elevated temperatures at which these plants operate. The metal alloys used for heat transfer surfaces and other components include copper-nickel alloys, nickel/chromium alloys, stainless steel, titanium, brass, and bronze. Based on the metallurgical composition of these alloys, the corrosion process could be expected to introduce copper, chromium, nickel, and zinc into the brine. The corrosion effect on the brine discharge metal loadings is less of a concern for the RO plants, with non-metallic membranes and ambient seawater operating temperatures.

The distilling plant anti-scaling compound used in Navy surface ships is Distiller Scale Preventive Treatment Formulation. The military specification requires anti-scaling compound products to contain organic polyelectrolytes such as polyacrylates, and an antifoaming agent in aqueous solution.[6] The polyelectrolyte chelates (ties-up) inorganic constituents (calcium, magnesium, metals) to prevent them from depositing on equipment surfaces. Equipment supplier material safety data sheets (MSDSs) indicate that the products contain about 10% to 20% polyacrylate and low levels of antifoaming chemicals (e.g., one product contains 1% polyethylene glycol). Ethylene oxide was identified on two of the MSDSs as potentially present in trace amounts. One of the MSDSs also indicated that acrylic acid, acetaldehyde, and 1,4-dioxane can also be present at trace levels.[7]

Distilling plant influent and effluent were sampled for materials that had a potential for being in the discharge. An aircraft carrier, an amphibious assault ship, and a landing ship dock were sampled.[8] Based on the brine generation process, system designs, and analytical data available, analytes in the metals, organics, and classicals classes were tested. In addition, Bis(2-ethylhexyl) phthalate, a semi-volatile organic compound, was specifically tested for, since it is not covered in the three aforementioned analyte classes, but is a standard parameter in sampling for semi-volatile constituents. The results of the sampling are provided in reference 8. Table 2 provides a list of all constituents and their concentrations that were detected in the discharge. In terms of thermal effects, this discharge is expected to be warmer than ambient water temperatures with a maximum overboard discharge temperature of 120 ^{o}F.

Priority pollutants that were detected included copper, iron, lead, nickel, and zinc; and the semi-volatile organic compound bis(2-ethylhexyl) phthalate. No bioaccumulators were detected.

3.4 Concentrations

The concentrations of detected constituents are listed in Tables 2 and 3.

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

The water purification plant brine annual discharge flow rate (Section 3.2) and constituent concentration data (Tables 2 and 3) were used to develop brine constituent effluent mass loading estimates. Similarly, constituent influent mass loadings were found by using the seawater annual flow rate (Section 3.2) and constituent concentration data (Tables 2 and 3).

The following general formula was used to determine influent mass loading and effluent mass loading:

$$\boxed{\begin{array}{c}\text{Mass Loading (lbs/yr)} = \\ \text{(concentration in µg/L) (flow rate in gal/yr) (3.7854 L/gal) (2.2 lb/kg) }(10^{-9}\text{ kg/µg)}\end{array}}$$

For instance, the estimated effluent mass loading for copper generated by distilling plant brine discharge is:

$$\boxed{\text{(217.38 µg/L) (2.47 billion gal/yr) (3.7854 L/gal)) (2.2 lb/kg) }(10^{-9}\text{ kg/µg) = 4471.48 lbs/yr}}$$

The estimated influent mass loading calculation for copper is:

$$\boxed{\text{(83.51 µg/L) (2.62 billion gal/yr) (3.7854 L/gal) (2.2 lb/kg) }(10^{-9}\text{ kg/µg) = 1822.11 lbs/yr}}$$

The mass loading of the discharge was then determined by subtracting the influent mass loading from the effluent mass loading for each constituent. Concentration values and mass loadings are provided in Table 2. Log-normal average concentrations were used because the sample data were assumed to approximate a log-normal distribution.

The mass loadings were calculated based upon flow from all distilling and RO plants and assuming constituent concentrations in distiller and RO effluent are equal. Calculations using this assumption are expected to overestimate mass loadings because constituent concentrations will be lower in RO effluent because the operating temperature is lower, resulting in less corrosion. Table 3 provides a water purification plant brine discharge mass loading summary.

4.2 Environmental Concentrations

Table 4 identifies distilling plant brine constituents that were detected at or above their respective Federal or most stringent state water quality criteria (WQC). Copper and zinc exceeded both Federal and most stringent state WQC. Nitrogen (as ammonia, nitrate/nitrite, and total kjeldahl nitrogen), phosphorous, iron, lead, nickel, and zinc exceed the most stringent state WQC.

4.3 Thermal Effects

The potential for distilling plant brine discharge to cause thermal environmental effects was evaluated by modeling the thermal plume generated and then comparing it to plumes representing state thermal discharge requirements. Thermal effects of distilling plant brine were modeled using the Cornell Mixing Zone Expert System (CORMIX) to estimate the plume size and temperature gradients in the receiving water body. The model was run under conditions that would overestimate the size of the thermal plume (minimal wind, slack tide) for the largest generator of distilling plant brine (aircraft carrier) and for a typical distillation brine generator (cruiser). The plume characteristics were compared to thermal mixing zone criteria for Virginia and Washington. Other coastal states require that thermal mixing zones be established on a case-by-case basis.

The Washington thermal regulations state 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 requires that the plume shall not constitute more than one-half of the receiving watercourse, and shall not extend downstream at any time a distance more than five times the width of the receiving of water body at the point of discharge.

The aircraft carrier distilling plant brine flow rate was determined to be 24,083 gallons per hour at a temperature of 104 °F while the cruiser flow parameters were 120 °F and 6,375 gallons per hour for temperature and flow rate, respectively. The ambient water temperature was dependent upon location and varied between 40 and 60 °F. Both modeled discharges were continuous and were assumed to emanate from a 6-inch diameter pipe located at the bottom of the hulls. The results of this modeling are provided in Table 5.[9]

Some of the model parameter assumptions lead to a reduced amount of mixing within the harbor. The assumptions are:

- wind velocity is at a minimum (1 m/s);
- the discharge will occur during a simulated slack tide event, using a minimum water body velocity (0.03 m/s);
- the average depth of water at the pier is 40 feet.

Using the above parameters and assumptions, distilling plant brine discharges from Armed Forces vessels do not exceed state thermal mixing zone criteria.

4.4 Potential for Introducing Non-Indigenous Species

The potential for introducing, transporting, or releasing non-indigenous species with this discharge is low because the maximum retention time of water in these plants is short; therefore the effluent is discharged in the same area from which the influent seawater is taken.

5.0 CONCLUSIONS

The discharge from vessel water purification plants has the potential to cause adverse environmental effects because significant amounts of metals are discharged at concentrations above WQC.

6.0 DATA SOURCES AND REFERENCES

Table 6 lists the data source of the information presented in each section of this NOD report.

<u>Specific References</u>

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3. UNDS Equipment Expert Meeting Minutes - Evaporator Brine & Reverse Osmosis (RO) Plant. August 27, 1996.

4. Aqua-Chem Marine, Inc. Marine Multi-Stage Flash Distilling Plants.

5. U.S. Navy. Commander, Naval Air Forces Pacific. Implementation of Uniform National Discharge Standards. Letter to SEA 00T-E1, 17 December 1996.

6. Specification for Distiller Scale Preventive Treatment Formulations (Metric), DOD-D-24577(2), 19 December, 1986.

7. Ashland Chemical Company. Material Safety Data Sheets - Ameroyal Evaporator Treatment, January 5, 1996.

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

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

General References

USEPA. Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B). 40 CFR Part 131.36.

USEPA. Interim Final Rule. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance – Revision of Metals Criteria. 60 FR 22230. May 4, 1995.

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

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

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

UNDS Ship Database, August 1, 1997.

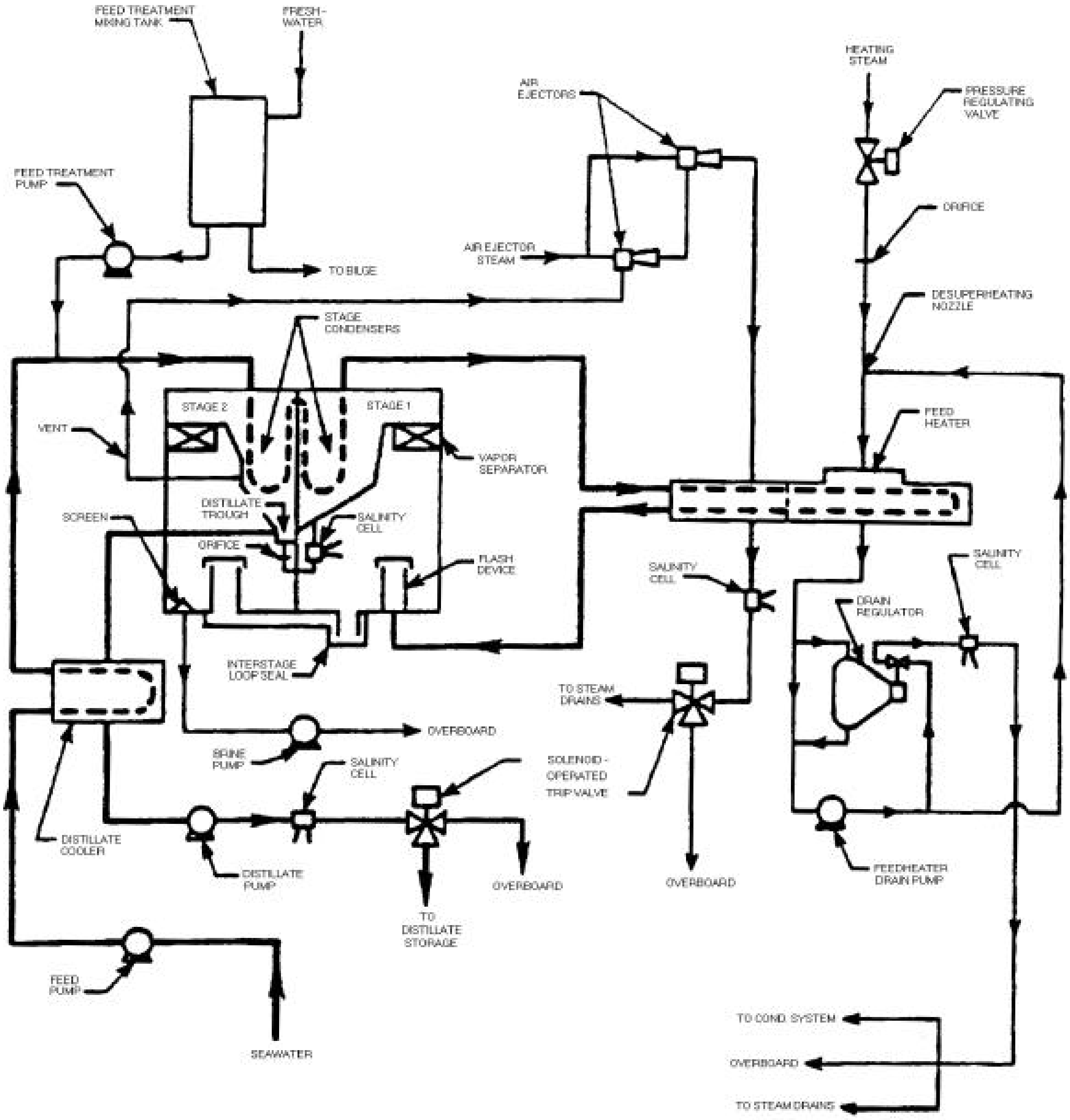

Figure 1. Diagram of a Two Stage Flash-Type Distilling Plant

Table 1. Water Purification Plant Discharge Summary

VESSEL CLASSIFICATION INFORMATION						WATER PURIFICATION SYSTEM			TRANSIT INFORMATION		ANNUAL BRINE WASTEWATER DISCHARGE (million gals/year)			
CLASS ID NO.	ARMED SVCE	CLASS NAME	VESSEL TYPE	NO. OF VESSELS	PRO-PULSION SYSTEM	TYPE AND NO. OF PLANTS	TOTAL H20 FLOW (gpd)	TOTAL BRINE FLOW (gpd)	TRAN-SITS	DAYS IN PORT	IN-PORT	IN TRANSIT	>12 n.m.	TOTAL
AE 26	MSC	Kilauea	Ammunition Ship	5	Steam	Distill / 2	32,000	544,000	8	26	35.4	1.8	918.5	955.6
AE 26	MSC	Kilauea	Ammunition Ship (ROS)	3	Steam	Distill / 2	32,000	544,000	8	26	9.8	1.1	551.1	562.0
AFS 1 (1)	MSC	Mars	Combat Store Ship (ROS)	1	Steam	Distill / 2	24,000	408,000	14	148	4.3	0.5	87.6	92.3
AFS 1 (3,5,6,7)	MSC	Mars	Combat Store Ship	4	Steam	Distill / 2	32,000	544,000	14	148	161.0	2.5	467.1	630.7
AFS 8	MSC	N/A	Combat Store Ship	3	Steam	Distill / 2	32,000	544,000	14	148	120.8	1.9	350.3	473.0
AG 194	MSC	Vanguard	Navigation Research Ship	1	Steam	Distill / 1	16,000	272,000	20	151	41.1	0.9	57.3	99.3
AG 195	MSC	Hayes	Sound Trials Ship	1	Diesel	RO 2	10,000	40,000	20	151	0	0	8.4	8.4
AGM 22	MSC	Converted Haskell	Missile Range Instrumentation Ship	1	Steam	Distill / 2	24,000	408,000	8	133	27.1	0.3	94.1	121.5
AGOS 1	MSC	Stalwart	Ocean Surveillance Ship	5	Diesel	Distill / 2	6,000	102,000	8	70	0	0	149.8	149.8
AGOS 19	MSC	Victorious	Ocean Surveillance Ship	4	Diesel	Distill / 2	6,000	102,000	10	107	0	0	104.6	104.6
AGS 26	MSC	Silas Bent and Wilkes	Surveying Ship	2	Diesel	Distill / 2	6,000	102,000	12	44	0	0	65.1	65.1
AGS 45	MSC	Waters	Surveying Ship	1	Diesel	Distill/ 2	15,324	260,508	2	7	0	0	93.2	93.2
AGS 51	MSC	John McDonnell	Surveying Ship	1	Diesel	RO/ 2	4,000	16,000	12	96	0	0	4.3	4.3
AGS 52	MSC	John McDonnell	Surveying Ship	1	Diesel	RO/ 3	6,000	24,000	12	96	0	0	6.4	6.4
AGS 60	MSC	Pathfinder	Surveying Ship	4	Diesel	RO/ 2	8,000	32,000	NA	NA	0	0	0	NA
AH 19	MSC	Mercy	Hospital Ship (ROS)	2	Steam	Distill/ 4	300,000	5,100,000	4	184	15.3	1.7	1839.4	1856.4
AKR 287	MSC	Algol	Vehicle Cargo Ship (ROS)	8	Steam	NA	NA	NA	6	109	NA	NA	NA	NA
AKR 295	MSC	NA	Vehicle Cargo Ship (ROS)	2	Diesel	Distill/ 1	9,511	161,687	NA	NA	0	0	NA	NA
AKR 296	MSC	NA	Vehicle Cargo Ship (ROS)	1	Diesel	Distill/ 4	8,200	139,400	NA	NA	0	0	NA	NA
ARC 7	MSC	Zeus	Cable Ship	1	Diesel	Distill/ 2	18,000	306,000	4	8	0	0	109.0	109.0
AO 187	MSC	Henry J. Kaiser	Oiler	12	Diesel	Distill 2	20,000	340,000	12	78	0	0	1162.8	1162.8
ATF 166	MSC	Powhatan	Fleet Ocean Tug	7	Diesel	RO/ 1	2,000	8,000	32	127	0	0	13.0	13.0
AO 177	NAVY	Jumboised Cimarron	Oiler	5	Steam	Distill/ 2	12,000	204,000	20	188	15.3	1.7	177.1	194.1
AOE 1	NAVY	Sacramento	Fast Combat Support Ship	1	Steam	Distill/ 2	100,000	1,700,000	22	183	28.1	3.1	303.2	334.3
AOE 1 (2-4)	NAVY	Sacramento	Fast Combat Support Ship	3	Steam	Distill/ 2	80,000	1,360,000	22	183	67.3	7.5	727.6	802.4
AOE 6	NAVY	Supply	Fast Combat Support Ship	3	Gas	Distill/ 2	60,000	1,020,000	12	114	0	0	761.9	761.9
ARS 50	NAVY	Safeguard	Salvage Ships	3	Diesel	Distill/ 2	8,000	136,000	44	208	0	0	61.1	61.1
ARS 50 (ARS 52)	NAVY	Safeguard	Salvage Ships	1	Diesel	Distill/ 3	12,000	204,000	44	208	0	0	30.5	30.5
AS 33	NAVY	Simon Lake	Submarine Tender	1	Steam	Distill/ 2	100,000	1,700,000	12	229	15.3	1.7	227.8	244.8

VESSEL CLASSIFICATION INFORMATION						WATER PURIFICATION SYSTEM			TRANSIT INFORMATION		ANNUAL BRINE WASTEWATER DISCHARGE (million gals/year)			
CLASS ID NO.	ARMED SVCE	CLASS NAME	VESSEL TYPE	NO. OF VESSELS	PRO-PULSION SYSTEM	TYPE AND NO. OF PLANTS	TOTAL H20 FLOW (gpd)	TOTAL BRINE FLOW (gpd)	TRAN-SITS	DAYS IN PORT	IN-PORT	IN TRANSIT	>12 n.m.	TOTAL
AS 39	NAVY	Emory S Land	Submarine Tender	3	Steam	Distill/ 2	100,000	1,700,000	12	293	45.9	5.1	357.0	408.0
CG 47	NAVY	Ticonderoga	Guided Missile Cruiser	27	Gas	Distill/ 2	24,000	408,000	24	166	0	0	2126.1	2126.1
CGN 36	NAVY	California	Guided Missile Cruiser	2	Nuclear	Distill/ 2	36,000	612,000	22	143	20.2	2.2	265.0	287.4
CGN 38	NAVY	Virginia	Guided Missile Cruiser	1	Nuclear	Distill/ 2	36,000	612,000	22	143	10.1	1.1	132.5	143.7
CV 59 (CV 62)	NAVY	Forrestal	Aircraft Carrier	1	Steam	Distill/ 5	380,000	6,460,000	14	137	27.1	3.0	1450.3	1480.4
CV 63	NAVY	Kitty Hawk	Aircraft Carrier	1	Steam	Distill/ 5	380,000	6,460,000	14	137	27.1	3.0	1450.3	1480.4
CV 63 (CV 64)	NAVY	Kitty Hawk	Aircraft Carrier	1	Steam	Distill/ 6	400,000	6,800,000	14	137	23.8	2.6	1526.6	1553.0
CVN 65	NAVY	Enterprise	Aircraft Carrier	1	Nuclear	Distill/ 5	350,000	5,950,000	12	76	21.4	2.4	1701.7	1725.5
CV 67	NAVY	Kennedy	Aircraft Carrier	1	Steam	Distill/ 5	450,000	7,650,000	14	137	32.1	3.6	1717.4	1753.1
CVN 68	NAVY	Nimitz	Aircraft Carrier	7	Nuclear	Distill/ 4	400,000	6,800,000	14	147	249.9	27.8	10210.2	10487.9
DD 963	NAVY	Spruance	Destroyer (Typical)	27	Gas	Distill/ 2	16,000	272,000	24	178	0	0	1329.3	1329.3
DD 963	NAVY	Spruance	Destroyer (DD 963 & DD 964)	2	Gas	RO/ 2	24,000	96,000	24	178	0	0	34.8	34.8
DD 963	NAVY	Spruance	Destroyer (DD 992)	1	Gas	Distill/RO 3	25,000	308,000	24	178	0	0	55.7	55.7
DD 997	NAVY	Spruance	Destroyer	1	Gas	Distill/ 2	24,000	408,000	24	178	0	0	73.8	73.8
DDG 51	NAVY	Arleigh Burke	Guided Missile Destroyer	18	Gas	RO/ 2	24,000	96,000	22	101	0	0	446.7	446.7
DDG 993	NAVY	Kidd	Guided Missile Destroyer	4	Gas	Distill/ 2	20,000	340,000	24	175	0	0	250.2	250.2
FFG 7	NAVY	Oliver Hazard Perry	Guided Missile Frigate	43	Gas	Distill/ 2	8,000	136,000	26	167	0	0	1119.9	1119.9
LCC 19	NAVY	Blue Ridge	Amphibious Command Ship	2	Steam	Distill/ 2	100,000	1,700,000	16	179	40.8	4.5	618.8	664.1
LHA 1	NAVY	Tarawa	Amphibious Assault Ship	5	Steam	Distill/ 2	140,000	2,380,000	18	173	160.7	17.9	2231.3	2409.8
LHD 1	NAVY	Wasp	Amphibious Assault Ship	4	Steam	Distill/ 2	200,000	3,400,000	26	185	265.2	29.5	2359.6	2654.3
LPD 4	NAVY	Austin	Amphibious Transport Dock	3	Steam	Distill/ 2	60,000	1,020,000	22	178	50.5	5.6	555.4	611.5
LPD 7	NAVY	Austin	Amphibious Transport Dock	3	Steam	Distill/ 2	60,000	1,020,000	24	188	55.1	6.1	523.3	584.5
LPD 14	NAVY	Austin	Amphibious Transport Dock	2	Steam	Distill/ 2	60,000	1,020,000	22	192	33.7	3.7	341.7	379.1
LPH 2	NAVY	Iwo Jima	Amphibious Assault Helicopter Carrier	2	Steam	Distill/ 2	100,000	1,700,000	22	186	56.1	6.2	589.9	652.2
LSD 36	NAVY	Anchorage	Dock Landing Ship	5	Steam	Distill/ 2	60,000	1,020,000	26	215	99.5	11.1	731.9	835.4
LSD 41	NAVY	Whidbey Island	Dock Landing Ship	8	Diesel	Distill/ 2	60,000	1,020,000	26	170	0	0	1538.2	1538.2
LSD 49	NAVY	Harpers Ferry	Dock Landing Ship	3	Diesel	Distill/ 2	60,000	1,020,000	NA	NA	0	0	NA	NA
MCM 1 (1-10)	NAVY	Avenger	Mine Countermeasure Vessel	10	Diesel	Distill/ 2	4,000	68,000	56	232	0	0	80.9	80.9
MCM 1 (11-14)	NAVY	Avenger	Mine Countermeasure Vessel	4	Diesel	Distill/RO 2	6,000	76,000	56	232	0	0	36.2	36.2

VESSEL CLASSIFICATION INFORMATION						WATER PURIFICATION SYSTEM			TRANSIT INFORMATION		ANNUAL BRINE WASTEWATER DISCHARGE (million gals/year)			
CLASS ID NO.	ARMED SVCE	CLASS NAME	VESSEL TYPE	NO. OF VESSELS	PROP-ULSION SYSTEM	TYPE AND NO. OF PLANTS	TOTAL H20 FLOW (gpd)	TOTAL BRINE FLOW (gpd)	TRAN-SITS	DAYS IN PORT	IN-PORT	IN TRANSIT	>12 n.m.	TOTAL
MHC 51	NAVY	Osprey	Coastal Minehunter Vessel	12	Diesel	RO/ 1	1,600	6,400	56	232	0	0	9.1	9.1
MCS 12	NAVY	Converted Iwo Jima	MCM Support Ship	2	Steam	Distill / 2	100,000	1,700,000	22	186	56.1	6.2	589.9	652.2
PC 1	NAVY	Cyclone	Coastal Defense Ship	13	Diesel	RO/ 3	1,200	4,800	36	105	0	0	15.7	15.7
SSN 637	NAVY	Sturgeon	Submarine	13	Nuclear	Distill / 1	8,000	136,000	14	NA	2.1	4.1	NA	NA
SSN 640	NAVY	Ben Franklin	Submarine	2	Nuclear	Distill / 1	8,000	136,000	14	NA	0.3	0.6	NA	NA
SSN 671	NAVY	Narwhal	Submarine	1	Nuclear	Distill / 1	8,000	136,000	14	NA	0.2	0.3	NA	NA
SSN 688	NAVY	Los Angeles	Submarine	56	Nuclear	Distill / 1	10,000	170,000	14	NA	11.1	22.2	NA	NA
SSBN 726	NAVY	Ohio	Submarine	17	Nuclear	Distill / 1	12,000	204,000	22	NA	6.4	12.7	NA	NA
WAGB 399	USCG	Polar	Icebreaker	2	Diesel	Distill / 2	16,000	272,000	NA	NA	0	0	NA	NA
WHEC 378	USCG	Hamilton/Hero Class	High Endurance Cutter	12	Diesel	Distill / 1	10,000	170,000	26	151	0	100.0	329.9	429.9
WIX 295	USCG	Eagle	Sailing Ship (Barque, Training)	1	Diesel	RO/ 2	7,600	30,400	24	265	0	0	2.9	2.9
WLB 180B	USCG	Balsam	Seagoing Tenders	2	Diesel	RO/ 1	500	2,000	10	120	0	0.0	0	0.0
WLB 225	USCG	Juniper	Seagoing Tenders	2	Diesel	Distill / 1	1,000	17,000	NA	NA	0	0	NA	NA
WMEC 210A	USCG	Reliance	Medium Endurance Class	5	Diesel	Distill / 1	3,000	51,000	18	149	0	59.9	60.0	119.9
WMEC 210B	USCG	Reliance	Medium Endurance Class	11	Diesel	Distill / 1	3,000	51,000	18	149	0	59.9	60.0	119.9
WMEC 213	USCG	Diver	Medium Endurance Class	1	Diesel	Distill / 1	3,000	51,000	18	98	0	7.0	20.0	27.0
WMEC 230	USCG	Storis	Medium Endurance Class	1	Diesel	Distill / 1	3,000	51,000	22	167	0	2.0	8.0	10.0
WMEC 270A	USCG	Bear	Medium Endurance Class	4	Diesel	Distill / 1	6,000	102,000	14	164	0	83.0	100.0	183.0
WMEC 270B	USCG	Bear	Medium Endurance Class	9	Diesel	Distill / 1	6,000	102,000	14	164	0	83.0	100.0	183.0
WPB 110A	USCG	Island	Patrol Craft	16	Diesel	RO/ 1	300	1,200	4	72	0	6.0	0	6.0
WPB 110B	USCG	Island	Patrol Craft	21	Diesel	RO/ 1	300	1,200	14	137	0	6.0	0	6.0
WPB 110C	USCG	Island	Patrol Craft	12	Diesel	RO/ 1	300	1,200	10	157	0	3.0	0	3.0
LSV	ARMY	NA	Logistics Support Vessel	6	Diesel	Distill/ 2	2,000	34,000	40	150	0	0.0	41.8	41.8
LCU-2000	ARMY	NA	2000 Class Landing Craft Utility	35	Diesel	RO/ 2	800	32,000	6	275	0	0.0	9.9	9.9
LT-128	ARMY	NA	128 ft Large Tug	6	Diesel	RO/ 2	600	2,400	10	245	0	0.0	1.7	1.7
			TOTALS:	541					1,480	10,957	1,836	616	43,575	46,027

Notes:

1. NA = Information not available; distilling plant assumed.
2. One transit = travel from sea to port, or from port to sea.
3. General Assumptions (typical or average per fleet):
    a. Vessel and submarine travel time in coastal waters (<12 n.m.) is 4 hours per transit.
    b. Steam propelled ships operate one distilling plant unit in port for an average of 3 days (4 hours for submarines) prior to departure (to fill boiler feed water tanks) and while transiting outbound through coastal waters. Ship distilling plants are operated at full capacity while at sea (>12 n.m.).
    c. Diesel and gas turbine propelled ships do not operate water purification systems in port or while transiting coastal waters.
    d. Daily Brine Flow = H20 Design Capacity times 17 for evaporation systems and 4 for RO systems..
4. MSC Water Purification Operating Criteria
    a. Steam propelled MSC ships operate at least one distilling plant unit at all times while in port, except for ships in reduced operating status (ROS).
5. Annual Brine Discharge Formulas:
    a. IN-PORT (steam propelled)
        1.) Navy and MSC ROS
        2.) MSC NON-ROS
    b. IN-TRANSIT (steam propelled)
    c. >12 n.m. (all ships)
6. Out of the 18 DDG51 Class ships currently in commission, DDG 52 through 63 do not have RO units. They have vapor compression distillers. There are plans to replace them with ROs in the future.

Table 2. Summary of Detected Analytes

Constituent	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Log Normal Mean	Frequency of Detection	Minimum Concentration	Maximum Concentration	Influent Mass Loading	Effluent Mass Loading	Mass Loading (Effluent - Influent)
	Evaporator Brine Influent				**Evaporator Brine Effluent**						
Metals	(μg/L)		(μg/L)	(μg/L)	(μg/L)		(μg/L)	(μg/L)	(lbs/yr)	(lbs/yr)	(lbs/yr)
Aluminum											
Dissolved	34.54	1 of 3	BDL	61.3	41.65	1 of 3	BDL	187	753.63	856.73	103.1
Total	370.83	2 of 3	BDL	2390	938.56	3 of 3	493.5	1380	8091.16	19306.05	11214.89
Arsenic											
Dissolved	~	~	~	~	2.93	2 of 3	BDL	10.9	~	60.27	60.27
Total	1.71	1 of 3	BDL	2	2.18	1 of 3	BDL	1	37.31	44.84	7.53
Barium											
Dissolved	12.51	3 of 3	7.1	17.8	21.21	3 of 3	17.5	23.8	272.96	436.29	163.33
Total	22.18	3 of 3	16.6	27.5	30.15	3 of 3	27	34.35	483.95	620.18	136.23
Boron											
Dissolved	2368.67	3 of 3	2140	2810	2472.67	3 of 3	2270	2775	51682.12	57033.44	5351.32
Total	2466.79	3 of 3	2030	3160	2588.76	3 of 3	2350	3115	53823	53250.44	(a)
Calcium											
Dissolved	227789.51	3 of 3	204000	267000	234484.79	3 of 3	210500	264000	4970149.71	4823320.15	(a)
Total	234025.72	3 of 3	193000	290000	243238.76	3 of 3	221000	287500	5106217.86	5003388.16	(a)
Copper											
Dissolved	29.97	2 of 3	BDL	404	59.21	3 of 3	49.7	71.15	653.92	1217.94	564.02
Total	83.51	3 of 3	12.7	1560	217.38	3 of 3	127	325.5	1822.11	4471.48	2649.37
Iron											
Total	594.59	3 of 3	107	2090	1081.50	3 of 3	576.5	1590	12973.39	22246.31	9272.92
Lead											
Dissolved	~	~	BDL	BDL	10.94	2 of 3	BDL	12.95	~	225.03	225.03
Total	6.77	1 of 3	BDL	2.7	23.84	2 of 3	BDL	24.4	147.71	490.39	342.68
Magnesium											
Dissolved	765931.19	3 of 3	699000	883000	783038.72	3 of 3	712500	904500	16711887.56	16106999.66	(a)
Total	781032.79	3 of 3	661000	978000	793166.24	3 of 3	693500	945500	17041390.06	16315321.37	(a)
Manganese											
Dissolved	11.10	3 of 3	3.5	24	9.83	3 of 3	6.6	12.5	242.19	202.20	(a)
Total	39.86	3 of 3	25.1	51.3	35.27	3 of 3	23.65	51.75	869.71	725.50	(a)
Molybdenum											
Dissolved	6.83	1 of 3	BDL	8.5	5.97	2 of 3	BDL	7.05	149.02	122.80	(a)
Total	8.57	2 of 3	BDL	14	6.72	2 of 3	BDL	15.4	186.99	138.23	(a)
Nickel											
Dissolved	32.40	1 of 3	BDL	500	9.71	1 of 3	BDL	20.1	706.94	199.73	(a)
Total	44.43	1 of 3	BDL	1290	13.17	2 of 3	BDL	32	969.42	270.91	(a)
Selenium											
Dissolved	~	~	BDL	BDL	13.83	1 of 3	BDL	42.9	~	284.48	284.48
Total	~	~	BDL	BDL	13.72	1 of 3	BDL	41.6	~	282.22	282.22
Sodium											
Dissolved	6733418.84	3 of 3	5840000	8500000	7096448.89	3 of 3	6190000	8585000	146916772.7	145972985.71	(a)
Total	6756605.00	3 of 3	5540000	8310000	7047726.17	3 of 3	6390000	8110000	147422672.6	144970766.01	(a)

Tin											
Dissolved	~	~	BDL	BDL	7.20	1 of 3	BDL	6.9	~	148.10	148.1
Total	~	~	BDL	BDL	14.68	3 of 3	8.2	42.1	~	301.97	301.97
Titanium											
Total	13.12	2 of 3	BDL	55.8	25.49	3 of 3	8.85	51.15	286.27	524.33	238.06
Zinc											
Dissolved	14.78	2 of 3	BDL	26.8	70.33	3 of 3	54.15	116.5	322.49	1446.68	1124.19
Total	18.49	2 of 3	BDL	43.9	122.26	3 of 3	92.95	174	403.43	2514.87	2111.44
Classicals	(mg/L)		(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(lb/yr)	(lb/yr)	(lbs/yr)
Alkalinity	82.44	3 of 3	70	92	91.50	3 of 3	76	105	1798762.12	1882142.52	83380.4
Ammonia as Nitrogen	0.07	1 of 3	BDL	0.11	0.17	2 of 3	BDL	0.33	1527.33	2262.68	735.35
Chemical Oxygen Demand	139.58	2 of 3	BDL	412	244.93	3 of 3	137	429	3045502.39	5038176.69	1992674.3
Chloride	12288.42	3 of 3	10900	15200	13260.50	3 of 3	11500	14800	268121596.3	272766676.27	4645080
HEM	3.83	1 of 3	BDL	9	2.86	1 of 3	BDL	5	83566.94	58829.81	(a)
Nitrate/Nitrite	0.02	1 of 3	BDL	0.2	0.02	1 of 3	BDL	0.22	436.38	411.39	(a)
Sulfate	1626.17	3 of 3	1360	1860	1629.17	3 of 3	1370	1890	35481477.38	33511804.68	(a)
Total Dissolved Solids	20202.53	3 of 3	18200	22100	20659.78	3 of 3	17700	26500	440799923.3	424968856.61	(a)
Total Kjeldahl Nitrogen	0.54	3 of 3	0.31	0.75	0.47	2 of 2	0.46	0.49	11782.28	9667.84	(a)
Total Organic Carbon	1.59	2 of 3	BDL	3.5	3.01	3 of 3	2.6	3.5	34692.28	61915.29	27223.01
Total Phosphorous	0.17	3 of 3	0.13	0.25	0.23	3 of 3	0.16	0.27	3709.24	4731.07	1021.83
Total Recoverable Oil & Grease	1.38	2 of 3	BDL	3.4	1.95	3 of 3	0.6	4.2	30110.28	40111.23	10000.95
Total Sulfide	5.77	3 of 3	4	8	5.52	3 of 3	4	7	125895.89	113545.65	(a)
Total Suspended Solids	48.34	3 of 3	32	107	85.04	3 of 3	27	386	1054732.66	1749261.20	694528.54
Volatile Residue	620.87	2 of 3	BDL	18200	594.19	2 of 3	BDL	18900	13546790.84	12222407.25	(a)
Organics	(µg/L)		(µg/L)	(µg/L)	(µg/L)		(µg/L)	(µg/L)	(lb/yr)	(lb/yr)	(lbs/yr)
4-Chloro-3-Methylphenol	~	~	BDL	BDL	20.94	2 of 3	BDL	75	~	430.73	430.73

BDL = Below Detection Limit

~ = Value could not be calculated because samples are BDL

(a) = Mass loading estimates were not determined for parameters for which the influent mass loading exceeded the effluent mass loading.

Table 3. Estimated Mass Loadings of Constituents

Constituent	**Log-normal Mean Influent (µg/L)**	**Log-normal Mean Effluent (µg/L)**	**Influent Mass Loading (lbs/yr)**	**Effluent Mass Loading (lbs/yr)**	**Estimated Annual Mass Loading (Effluent - Influent) (lbs/yr)**
Ammonia as Nitrogen	0.07	0.17	1527.33	2262.68	735.35
Nitrate/Nitrite	20	20	436.38	411.39	-24.99
Total Kjeldahl Nitrogen	540	470	11782.28	9667.84	-2114.44
Total Phosphorous	0.17	0.23	3709.24	4731.07	1021.83
Copper					
Dissolved	29.97	59.21	653.92	1217.94	564.02
Total	83.51	217.38	1822.11	4471.48	2649.37
Iron					
Total	594.59	1081.50	12973.39	22246.31	9272.92
Lead					
Total	6.77	23.84	147.71	490.39	342.68
Nickel					
Total	44.43	13.17	969.42	270.91	-698.51
Zinc					
Total	18.49	122.26	403.43	2514.87	2111.14

Notes:

1. The table lists all constituents whose effluent log-normal mean concentration exceeds the Federal or most stringent state water quality criteria. 2. The average total concentration is the log-normal mean for a constituent, determined from Table 2, by subtracting the influent total average (background) concentration from the effluent total average concentration.
3. Mass loadings are based on average total concentrations and a total fleet brine discharge flow estimate of 2.47 billion gallons per year to navigable waters less than 12 n.m. from shore (1.84 billion gallons per year in port and 0.62 billion gallons per year in transit, from Table 1). Mass loading was not determined for nickel, for which the influent concentration exceeded the effluent concentration.

Table 4. Mean Concentrations of Constituents that Exceed Water Quality Criteria

Constituent	Log-normal Mean Effluent	Minimum Concentration Effluent	Maximum Concentration Effluent	Federal Acute WQC	Most Stringent State Acute WQC
Classicals (μg/L)					
Ammonia as Nitrogen	170	BDL	330	None	6 (HI)[A]
Nitrate/Nitrite	20	BDL	220	None	8 (HI)[A]
Total Kjeldahl Nitrogen	470	460	490	None	-
Total Nitrogen[B]	490			None	200 (HI)[A]
Total Phosphorous	230	160	270	None	25 (HI)[A]
Metals (μg/L)					
Copper					
Dissolved	59.21	49.7	71.15	2.4	2.4 (CT, MS)
Total	217.38	127	325.5	2.9	2.5 (WA)
Iron					
Total	1081.5	576.5	1590	None	300 (FL)
Lead					
Total	23.84	BDL	24.4	217.2	5.6(FL, GA)
Nickel					
Total	13.17	BDL	32	74.6	8.3 (FL, GA)
Zinc					
Total	122.3	93.0	174	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 5. Summary of Thermal Effects of Distilling Plant Brine Discharge[9]

CASE	Discharge Temp (°F)	Discharge Flow (gallons per hour)	Ambient Water Temp (°F)	Predicted Plume Length (m)	Allowable Plume Length (m)	Predicted Plume Width (m)	Allowable Plume Width (m)	Predicted Plume Depth (m)
Virginia State (3.0°C ΔT)								
4a (CV 63)	104	24,083	40	3.8	32,000	0.43	3,200	0.43
4b (CGN 36)	120	6,375	40	2.57	32,000	0.35	3,200	0.35
Washington State (0.3°C ΔT)								
4a (CV 63)	104	24,083	50	16.42	73	1.83	400	1.83
4b (CGN 36)	120	6,375	50	7.72	73	19.28	400	0.96

Table 6. Data Sources

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

[a] NSTM - Naval Ships' Technical Manual
[b] MSDS - Material Safety Data Sheet