This document contains the 2004 Holland America Veendam Sampling Episode Report for sampling episode 6503. The report and all the appendices can be downloaded from ***http://www.epa.gov/owow/oceans/cruise_ships/veendam.html***

Holland America Veendam

Sampling Episode Report

March 2006

United States Environmental Protection Agency

Sampling Episode Report
Holland America Veendam
Sampling Episode 6503

U.S. Environmental Protection Agency

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ACKNOWLEDGMENT AND DISCLAIMER

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EXECUTIVE SUMMARY

Sampling Episode Report for Holland America Veendam

This Sampling Episode Report describes the sampling and analysis activities to characterize wastewater (graywater and sewage) generated and discharged by the cruise vessel Holland America Veendam while in Alaska waters. This sampling took place from June 20 through June 25, 2004, under the direction of the U.S. Environmental Protection Agency (EPA). The sampling program is part of EPA's data collection effort to evaluate whether to develop wastewater discharge standards, under 33 USC 1901 Note, for cruise vessels authorized to carry 500 or more passengers for hire when operating in the waters of the Alexander Archipelago or the navigable waters of the United States within the State of Alaska or within the Kachemak Bay National Estuarine Research Reserve. EPA will use information from the sampling of this vessel and three other cruise ships in Alaska to characterize wastewater generated and discharged by large cruise vessels with advanced wastewater treatment systems.

EPA selected the Holland America Veendam to characterize the performance of the Zenon Environmental Inc. membrane bioreactor treatment system, an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration and ultraviolet disinfection. Samples were collected of various wastewater sources (laundry, accommodations, food pulper, and galley wastewater); influent to the treatment system (combined graywater and sewage); influent to the ultraviolet (UV) disinfection component of the treatment system; effluent from the treatment system; source water; wastewater treatment residuals (screening solids and wastewater biosludge); and incinerator ash. Wastewater source samples were collected for a single 24-hour sampling period, while samples of the influent to and effluent from the treatment system were collected for five consecutive 24-hour sampling periods.

Strap-on ultrasonic flow meters were installed near the sampling locations for laundry wastewater, influent to treatment, and effluent from treatment to collect flow data and, in some cases, to trigger automatic sampling machines. In addition, flow data were collected from the Veendam's in-line flow meters installed on the graywater and sewage feeds to the treatment

system (which, combined, represent the influent to the treatment system) and on the effluent from the treatment system.

Various sample collection methods (composite by flow, composite by time, grab, and grab composite) were used depending on the sampling point and analyte. Tested analytes included pathogen indicators (fecal coliform, *E. coli*, enterococci), classical pollutants, total and dissolved metals, volatile and semivolatile organics, pesticides, polychlorinated biphenyls, and dioxins and furans. Not all samples were analyzed for all target analytes.

The food pulper wastewater samples showed the highest concentration among graywater sources for the majority of analytes, most notably *E. coli* and enterococci, oil and grease, nutrients, and solids. Accommodations wastewater samples had the highest concentration for 11 of the analytes, including fecal coliform, organics, and several metals. Laundry wastewater samples showed the highest concentration for five analytes, including alkalinity and several dissolved metals.

Because of water conservation measures onboard cruise ships (such as vacuum toilets), key analytes such as pathogen indicators, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and total suspended solids (TSS) are found at much higher concentrations in the influent to the Veendam wastewater treatment system than in typical domestic wastewater. Of the 54 metal analytes tested for, 27 were detected in every influent to treatment system sample. Among the 365 target analytes for volatile and semivolatile organics, pesticides, and polychlorinated biphenyls, only 9 were detected in any influent to treatment samples, most at concentrations close to their detection limits.

The Zenon treatment system successfully removed almost all pathogen indicators (>99%) and most classical pollutants, metals, and organics. Two pathogen indicators, fecal coliform and *E. coli*, were not detected in any of the 15 effluent treatment samples, while one indicator, enterococci, was detected in 2 samples at close to the detection limit. The treatment system removed almost all BOD_5 (>99%), COD (97%), total organic carbon (TOC) (93%), settleable residue (>99%) and TSS (>99%). The treatment system reduced ammonia, total

Kjeldahl nitrogen (TKN, which measures both ammonia and organic forms of nitrogen), and total phosphorus by approximately 75%, while nitrate/nitrite levels remained relatively unchanged. The treatment system was highly efficient at removing particulate metals, and removed dissolved metals at an average of 37%. The treatment system removed most of the volatile and semivolatile organics to concentrations below detection levels.

The Zenon wastewater treatment system generates two types of residual waste: screening solids (from two coarse screens at the beginning of the treatment system) and waste biosludge (excess biological mass from the treatment system's bioreactor). Screening solids are collected monthly for disposal on shore. Waste biosludge is pumped to a double-bottom holding tank for overboard discharge outside of 12 nautical miles from shore. Most of the analytes detected in these residual wastes were also detected in the influent to the treatment system. For many analytes, concentrations in the screening solids and waste biosludge exceeded those in the influent to treatment, suggesting that these analytes are removed from the system in these waste streams.

On average, each person generated approximately 62 gallons of untreated sewage (17 gallons) and graywater (45 gallons) per day. The average discharge from the treatment system was approximately 58 gallons of treated wastewater per person per day.

1.0 INTRODUCTION

This Sampling Episode Report describes the Environmental Protection Agency's sampling and analysis activities to characterize graywater and sewage generation and treatment by Holland America Line's cruise ship ms Veendam (Veendam) while in Alaska waters. This sampling episode took place from June 20 through June 25, 2004, under the direction of the Engineering and Analysis Division of the Office of Science and Technology, and the Oceans and Coastal Protection Division of the Office of Wetlands, Oceans, and Watersheds of the U.S. Environmental Protection Agency (EPA).

The Veendam is a 55,451 gross-ton cruise vessel launched in 1996. The vessel has 10 decks, a length of 720 feet, and a beam of 101 feet. The Veendam's maximum cruising speed is 22 knots. Its port of registry is Nassau, Bahamas. During the sampling episode, the Veendam carried approximately 1,300 passengers and 520 crew. The ship's itinerary was as follows:

Date	Port
June 20, 2004	Seward, Alaska
June 21, 2004	Cruising College Fjord
June 22, 2004	Cruising Glacier Bay
June 23, 2004	Sitka, Alaska
June 24, 2004	Juneau, Alaska
June 25, 2004	Cruising Inside Passage
June 26, 2004	Vancouver, BC

This sampling episode is part of EPA's data collection efforts to evaluate whether to develop wastewater discharge standards for cruise vessels authorized to carry 500 or more passengers for hire when operating in the waters of the Alexander Archipelago or the navigable waters of the United States within the State of Alaska or within the Kachemak Bay National Estuarine Research Reserve (hereafter referred to as Alaska waters). Such regulations are authorized by "Title XIV - Certain Alaskan Cruise Ship Operations" of the Miscellaneous Appropriations Bill (H.R. 5666) passed by Congress on December 21, 2000, in the Consolidated

Appropriations Act of 2001 (Pub L. 106-554, Sections 1401-1414, 33 USC 1901 Note). The data and information gathered through this sampling episode were collected using EPA's authority under section 308 of the Clean Water Act, as also provided by Title XIV. Holland America Line voluntarily provided information and data gathered for and represented in this report, notwithstanding the above cited authority, in the interest of research for the improvement of wastewater treatment standards.

EPA selected the Veendam to characterize the performance of the Zenon Environmental Inc. (Ontario, Canada) membrane bioreactor treatment system (Zenon treatment system), an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration, using the proprietary ZeeWeed® membrane technology, and ultraviolet (UV) disinfection. EPA will use the analytical and flow data included in this sampling episode report to evaluate the performance of the Zenon treatment system, and to analyze patterns and variability in wastewater sources.

Samples were collected in accordance with prodcedures specified in the *Generic Sampling and Analysis Plan for Large Cruise Ships in Alaska Waters* (Generic SAP) and the ship-specific *Sampling and Analysis Plan for Holland America Veendam* (Veendam SAP). The Veendam SAP is presented in Appendix E and the Generic SAP is available on EPA's website at http://www.epa.gov/owow/oceans/cruise_ships/GenericSAP040602.pdf. Pathogen indicator analyses were performed onboard. Samples for all other analyses were shipped to shoreside laboratories for analysis. Appendix D identifies all EPA-contract laboratories used in this sampling episode.

Section 2.0 of this report describes the generation, collection, and treatment of graywater and sewage on the Veendam, as well as the sampling point and flow meter locations used in this sampling episode. Section 3.0 describes the sample collection methods and deviations from the Veendam SAP. Section 4.0 presents and analyzes the analytical, flow, and shipboard data collected during the sampling episode. Section 5.0 describes the quality assurance and quality control (QA/QC) procedures and results. Section 6.0 presents references

used in this document. Tables and figures referred to in the text are located at the end of each section.

2.0 WASTEWATER SYSTEM AND SAMPLING POINTS

This section describes graywater and sewage generation, collection, and treatment on the Veendam, as well as the sample collection points and flow meter locations and installation points used in this sampling episode.

2.1 Wastewater Generation and Collection

The ship's collection, holding, and transfer system (CHT) collects and transfers graywater and sewage generated onboard to the ship's Zenon treatment system. For the purpose of this report, graywater refers to non-sewage wastewaters that are collected by the CHT system. The CHT system is composed of five subsystems, referred to by the ship's crew as the galley, food pulper, accommodations, laundry, and sewage systems. Figure 2-1 is a simplified diagram of the Veendam's graywater and sewage CHT system. Wastewater sources collected by each of the five subsystems are described in Table 2-1. Potable water is used as source water for all ship operations that generate graywater and sewage (e.g., laundry, galley, food pulper, sinks, showers, and toilets). Potable water is produced onboard and bunkered while in port, with each source providing approximately half of the fresh water requirements for the ship.

2.2 Wastewater Treatment

The Veendam is outfitted with a Zenon treatment system, an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration and ultraviolet (UV) disinfection. Figure 2-2 is a simplified diagram of the Zenon treatment system.

Wastewater from the laundry, accommodations, food pulper, and galley CHT subsystems culminates in two graywater storage tanks, while the sewage CHT subsystem culminates in four sewage collection tanks. Wastewater pumped from the graywater storage tanks and sewage collection tanks mixes in a common line, flows through two coarse screens operated in parallel, and enters a collection tank. From the collection tank, the wastewater is

pumped to two aerated bioreactor and membrane chamber treatment trains operated in parallel. Operators add defoamer (rarely) and caustic (for pH control) to the bioreactors as needed. From the bioreactors, the wastewater is pumped to the membrane chambers where it flows through the proprietary ZeeWeed® hollow-fiber ultrafiltration membrane system under a vacuum. Particulate matter and mixed liquor (wastewater containing organic matter and biological floc) remain in the membrane chambers. Coarse air diffusers scour the membrane exteriors to remove accumulated solids, and these solids, along with the mixed liquor and particulate matter, overflow from the membrane chambers back to the bioreactor tanks. The system also backwashes the membranes every eight minutes to keep the membranes clean; this backwash remains in the system. Citric acid and sodium hypochlorite are added to the membrane backwash tanks on alternate days to enhance cleaning. In the final stage of treatment, the combined wastewater from the membranes undergoes UV disinfection. The hydraulic residence time of the bioreactor and membrane chamber (i.e., the amount of time the wastewater stays in the treatment system) is less than one day.

According to the ship's crew, the Zenon treatment system can treat 700 m^3 (185,000 gallons) per day of wastewater generated onboard. This is well in excess of its typical daily load, approximately 350 m^3 (9,250 gallons), as determined by interviews with the ship's crew and measured flows collected during this sampling episode.

The Zenon treatment system operates continuously, regardless of the ship's location (e.g., in port, at sea within Alaska waters, at sea outside Alaska waters). The vessel typically continuously discharges treated wastewater from this system overboard. When overboard discharge is restricted, such as when the cruise vessel enters Glacier Bay National Park, the treated effluent is diverted to double-bottom holding tanks, where it is held for eventual discharge overboard outside 12 nautical miles (nm).

The Zenon wastewater treatment system generates two types of residual waste: screening solids (from the 2 coarse screens) and waste biosludge (excess biological mass from the bioreactor). A solids collection tank located directly beneath the screens collects the screening solids and uses a macerator pump to chop the solids. Macerating the solids releases

additional water. Therefore, four to five times per day, the Zenon operator pumps the contents of the solids tank back to the screens to remove excess water. Once a month, the Zenon operator removes approximately 15 to 20 m^3 of screening solids from the solids collection tank and disposes of it onshore.

Waste biosludge is removed (or "wasted") from the bioreactors daily. The Zenon operator calculates the recommended waste biosludge volume to remove by measuring the bioreactor total suspended solids (mixed-liquor suspended solids (MLSS)) concentration. In Alaska, the target MLSS concentration for the Zenon bioreactor is 9,000 to 10,000 mg/L. To maintain the target MLSS concentration, the typical daily biosludge volume wasted is 15 m^3. If additional waste volume is required, e.g., 20 m^3, then the Zenon operator would waste 15 m^3 in the morning and an additional 5 m^3 in the evening. Waste biosludge is held in a double-bottom holding tank for overboard discharge outside of 12 nm from shore.

The ultrafiltration membranes require more intensive cleaning every few weeks for optimal operation. The Zenon operator initiates the membrane cleaning cycle when the differential pressure across the membranes, or transmembrane pressure (TMP), reaches approximately -0.45 bars. The 2-day cleaning cycle requires shutdown of the bioreactor/membrane chamber treatment train. (When one bioreactor/membrane chamber is being cleaned, all wastewater is diverted to the second, parallel bioreactor/membrane chamber.) The first step in the cleaning cycle is the addition of two drums (406 L in total) of sodium hypochlorite to the membrane chamber, plus a sufficient amount of treated wastewater to fill the chamber. The hypochlorite solution remains in the chamber overnight and is then sent to a double-bottom holding tank (the same tank used to hold waste biosludge) for discharge overboard outside 12 nm. The second step is to add 150 kg of citric acid to the membrane chamber, plus a sufficient amount of treated wastewater permeate to fill the chamber. The solution remains in the chamber for six hours and is then sent to the same double-bottom holding tank.

During periods of reduced treatment capacity (e.g., maintenance, cleaning, high TMP), additional untreated graywater storage capacity may be needed. The two graywater

storage tanks routinely used by the treatment system provide a combined holding capacity of 240 m^3. Additional double-bottom holding tanks provide up to 740 m^3 of additional storage capacity, yielding a total holding capacity of 980 m^3. Note that tank piping configurations allow the contents of only some of the additional double-bottom holding tanks to be pumped to the wastewater treatment system. Any untreated graywater stored in tanks that cannot be pumped to the treatment system is held for discharge without treatment outside 12 nm from shore. According to the ship's crew, such discharges are not typical and occur infrequently.

2.3 Wastewater and Residual Sample Collection Points

Samples were taken from the graywater sources (galley, laundry, accommodations, and food pulper); influent to the treatment system (combined graywater and sewage); influent to the UV disinfection portion of the treatment system; effluent from the treatment system; source water (water from the ship's potable water system); wastewater treatment residuals; and incinerator ash. Table 2-1 describes the wastewaters sampled, their sampling point locations, their flow measurement locations (if applicable), and the number of days they were sampled. Table 2-2 provides the same information for the treatment residuals and incinerator ash sampled. In general, graywater source and wastewater treatment residual samples were taken for one 24-hour period, while samples of the influent to and effluent from the treatment system were taken for five 24-hour periods. See Section 3.2 and Table 3-2 for information on the analytes tested.

Samples were collected from the ship's potable water system (source water) to determine if any of the target analytes were present as background contamination. One trip blank was prepared and analyzed for volatile organics to evaluate possible contamination during shipment and handling of samples. Finally, an equipment blank was prepared and analyzed to evaluate possible contamination caused by the sampling equipment.

Samples were not taken directly from the sewage CHT system. In addition, samples could not be collected of wastewater held in double-bottom holding tanks for discharge outside 12 nm from shore (i.e., treated effluent diverted to storage while the ship cruised Glacier

Bay) because (1) double-bottom holding tanks cannot be accessed directly due to safety considerations, and (2) sampling from the holding tank discharge manifold would characterize combined holding tank discharges and not discharges specific to the holding tanks of interest.

2.4 Flow Meter Locations

Strap-on ultrasonic flow meters (Controlotron Model 1010) were installed at three sampling locations to collect flow data and, in some cases, to control automatic composite sample machines (by triggering sample collection after a defined amount of flow passed through the pipe). The first location was near the influent to the wastewater treatment system (SP-6/7; see Table 2-1 for a description of wastewaters and Figure 2-2 for a simplified wastewater treatment system diagram showing sampling points.) This flow meter was installed on the outlet pipe from the screens because there was not a suitable location on the inlet pipe to the screens. The second location was at the effluent from the wastewater treatment system (on the overboard discharge line for the treated effluent, SP-9/10; see Table 2-1 and Figure 2-2). This flow meter was installed on the same piping as the sample tap. The third location was laundry wastewater (SP-1/2; see Table 2-1 and Figure 2-1). This flow meter was installed on the outlet pipe from the laundry wastewater holding tank. The sample tap, however, was installed on the inlet pipe to the laundry wastewater holding tank because there was not a suitable location on the outlet pipe. The flow meter at this location was not used to control sample collection at this sampling point because the flow patterns at the flow meter and sample tap locations were not the same. Therefore, composite sample collection at this sampling point was time-weighted (see Table 3-1 for a description of the sample collection methods).

Sampling points for accommodations and galley wastewaters were located on piping that would not support the installation of strap-on ultrasonic flow meters (see Table 2-1), precluding collection of flow data and flow-weighted composite samples at these sampling points. Time-weighted composite samples were collected at the accommodations and galley wastewater sampling points (see Table 3-1 for a description of the sample collection methods). Flow estimates for the food pulper wastewater were provided by the ship's crew.

In addition, flow data were collected from three of the Veendam's in-line Endress + Hauser Pro-mag series flow meters (see Figure 2-2 for locations). One of these in-line flow meters was on the discharge line from the sewage collection tanks. The second was on the discharge line from the graywater storage tanks. Flow from these two meters combined represents the total flow into the treatment system. The third in-line flow meter from which data were collected was on the effluent from the wastewater treatment system (i.e., on the overboard discharge line for the treated effluent), which was the same location where a strap-on flow meter was installed.

Table 2-1

Wastewater, Sampling Point, and Flow Meter Descriptions
Holland America Veendam

Descriptions of wastewaters sampled, sampling point locations, flow meter locations, and number of days sampled for the Veendam sampling episode (June 20 through June 25, 2004).

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Laundry	Wastewater from laundry equipment and laundry floor drains. It does not include wastewater from dry cleaning operations or passenger laundrettes. All laundry wastewater drains to a single laundry wastewater holding tank.	SP-1/2	Sample tap was installed on the inlet pipe to the laundry wastewater holding tank. Sample tap could not be installed on the holding tank outlet pipe due to commingling with other graywater sources caused by backflow from the graywater main common line.	Strap-on flow meter was installed on the outlet pipe from the laundry wastewater holding tank. Backflow from the graywater main common line did not significantly affect the measured laundry wastewater flows. Strap-on flow meter was not suitable for gravity flow piping (i.e., piping that is not full) at the inlet to the holding tank.	1 (Day 4)
Accommodations	Wastewater from sinks, tubs, and showers in guest and crew rooms, bar sinks, salon sinks and floor drains, most interior deck drains, passenger laundrettes, dry cleaning noncontact cooling water, and non-engine-room shop sinks. Accommodations wastewater is pretreated by gross particle filters as it drains to three accommodations wastewater holding tanks approximately equal in size.	SP-3	Sample tap was installed on the outlet pipe from one of the holding tanks. According to the ship's crew, all three holding tanks receive similar wastewater; therefore, the specific holding tank sampled was selected based on accessibility.	Flow data for accommodations wastewater were not obtained. Strap-on flow meter set-up and calibration procedures were unsuccessful at the outlet pipe from the accommodations wastewater holding tank, most likely due to poor pipe flow conditions such as pipe scaling or extreme aeration. Strap-on flow meter was not suitable for gravity flow piping (i.e., piping that is not full) at the inlet to the holding tank.	1 (Day 4)

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and wastewater treatment systems indicating the sampling point and flow meter locations.
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(d) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day.

Table 2-1 (Continued)

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Food Pulper	Wastewater from the Somat food pulper system. Food waste is mixed with water and processed into a slurry. The food slurry is then separated into semi-dry food solids and wastewater (food pulper wastewater). Food solids are incinerated onboard, while food pulper wastewater is routed to a food pulper wastewater holding tank for recirculation back to the Somat system. Three to four times per day, the food pulper wastewater is drained from the holding tank to the wastewater treatment system and replaced with fresh water.	SP-4	Samples were collected from an existing sample tap located on the holding tank, just prior to the times the tank contents were drained to wastewater treatment.	Flow measurements not required. Approximately 22 m^3 of food pulper wastewater is generated per day, according to the ship's crew.	1 (Day 3)
Galley	Wastewater from dishwashers, food preparation, galley sinks, and galley and garbage room floor drains. Galley wastewater drains from each of the two passenger galleys and one crew galley, through three grease traps (one for each galley), into a single combined galley wastewater holding tank. An enzyme is added prior to the grease traps to help degrade grease.	SP-5	Sample tap was installed on the inlet pipe to one of the passenger galley grease traps. According to the ship's crew, all three grease traps receive similar wastewater; therefore, the specific grease trap sampled was selected based on accessibility.	Flow data for galley wastewater were not obtained. Strap-on flow meter was not suitable for gravity flow piping (i.e., piping that is not full) at the inlet to the grease trap. Pipe configurations precluded all other locations.	1 (Day 2)

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and wastewater treatment systems indicating the sampling point and flow meter locations.
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(d) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day.

Table 2-1 (Continued)

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Influent to Zenon Treatment System	Combined wastewaters from the five collection, holding, and transfer (CHT) subsystems (laundry, accommodations, food pulper, galley, and sewage). A vacuum CHT system conveys sewage from passenger and crew toilets and urinals. The sewage CHT system also conveys wastewater from medical facility sink and floor drains. Note that samples were not taken directly from the sewage CHT system. Wastewater from the laundry, accommodations, food pulper, and galley CHT subsystems culminates in two graywater storage tanks. The sewage CHT subsystem culminates in four sewage collection tanks (one of the sewage collection tanks also receives 14 m^3/day of treated effluent for dilution). Wastewater from the graywater storage tanks and sewage collection tanks mixes in a common line as it flows to the treatment system.	SP-6/7	Sample tap was installed on the combined graywater and sewage inlet pipe to the treatment system (before the screens).	Strap-on flow meter was installed on the outlet pipe from the screens because there was not a suitable location on the inlet pipe to the screens. The Veendam has in-line flow meters installed on the discharge line from the graywater storage tanks and on the discharge line from sewage collection tanks, prior to the point where the wastewaters are combined for treatment. The combined flow from these two flow meters represents the influent to wastewater treatment.	5
Influent to UV Disinfection part of Zenon Treatment System	Wastewater following treatment by biological oxidation and ultrafiltration but prior to ultraviolet (UV) disinfection.	SP-8	Sample tap was installed on the inlet pipe to the UV disinfection unit.	Flow measurements not required.	5
Effluent from Zenon Treatment System	Final treated wastewater effluent from the Zenon wastewater treatment system. Effluent is typically continuously discharged overboard. Where discharge is prohibited (e.g., Glacier Bay), wastewater is diverted to storage in double-bottom holding tanks for overboard discharge outside 12 nm from shore.	SP-9/10	Sample tap was installed on the effluent pipe from UV disinfection, upstream of the diversion valve that directs wastewater to either overboard discharge or to storage in double-bottom holding tanks. Piping distance from the effluent sample tap to the overboard discharge port is 10.5 m.	Strap-on flow meter was installed on the effluent pipe from UV disinfection just prior to the overboard discharge port and downstream of the diversion valve that directs wastewater to either overboard discharge or storage in double-bottom holding tanks. The Veendam has an in-line flow meter installed at the same location.	5

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and wastewater treatment systems indicating the sampling point and flow meter locations.
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(d) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day.

Table 2-1 (Continued)

Wastewater Name	Wastewater Description (a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Source Water	Potable water used as source water for all systems that generate wastewater that is treated by the Zenon treatment system.	SP-15	Samples collected from a passenger cabin sink located forward in the ship (i.e., a point farthest in the distribution line).	Flow measurements not required.	5 / 1 (d)

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and wastewater treatment systems indicating the sampling point and flow meter locations.
(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(d) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day.

Table 2-2

Treatment Residuals and Incinerator Ash Descriptions
Holland America Veendam

Descriptions of treatment residuals and incinerator ash sampled, sampling point locations, flow meter locations, and number of days sampled for the Veendam sampling episode (June 20 through June 25, 2004).

Treatment Residual Name	Treatment Residual Description	Sampling Point # (a)(b)	Sampling Point Description (a)	Flow Meter Description	# of Days Sampled
Screening Solids	Solids generated by the screens of the Zenon wastewater treatment system. Screening solids are collected monthly from the solids collection tank for disposal onshore.	SP-11	Sample tap was installed on the solids recirculation loop at the macerating pump.	Flow measurements not required. Approximately 15 to 20 m^3 of screening solids are generated per month, according to the ship's crew.	1 (Day 1)
Waste Biosludge	Waste biosludge removed daily from the bioreactors of the Zenon wastewater treatment system. Waste biosludge is pumped to a double-bottom holding tank for overboard discharge outside of 12 nm from shore.	SP-12	Sample tap was installed on the piping that routes the waste biosludge from the treatment system to the double-bottom holding tank.	Flow measurements not required. Approximately 15 m^3 of waste biosludge is generated per day, according to the ship's crew.	1 (Day 2)
Incinerator Ash	Ash generated from the incineration of trash (e.g., cardboard, paper, plastic) and food solids from the Somat food pulper system. Incinerator ash is collected in incinerator ash storage hoppers for disposal onshore.	SP-13/14	Samples were collected directly from an incinerator ash storage hopper.	Flow measurements not required.	1 (Day 1)

(a) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and wastewater treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.

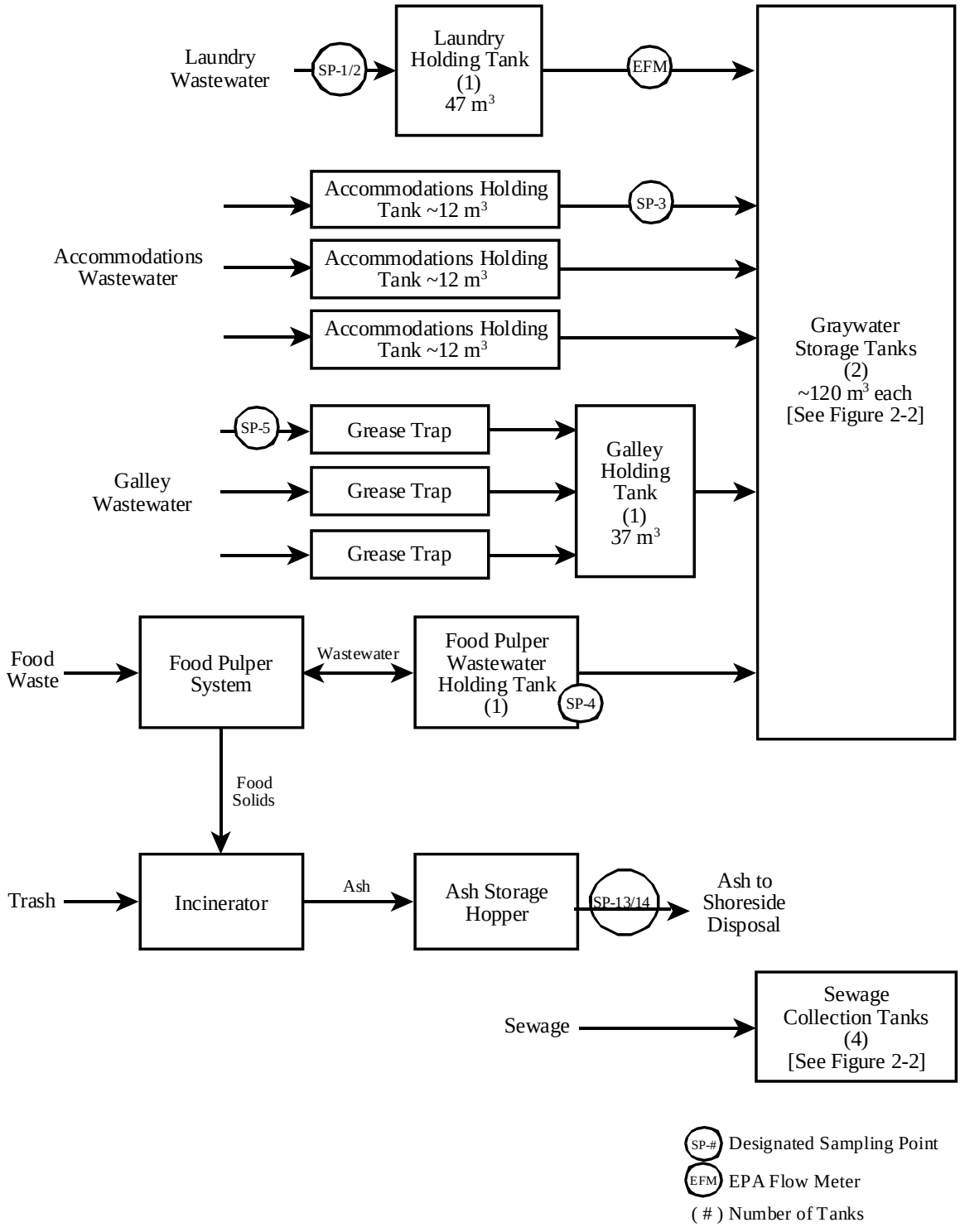

Figure 2-1. Graywater and Sewage Collection, Holding and Transfer System, Holland America Veendam

Simplified diagram of the Holland America Veendam graywater and sewage CHT System. See Table 2-1 for a list of wastewater streams in each wastewater source.

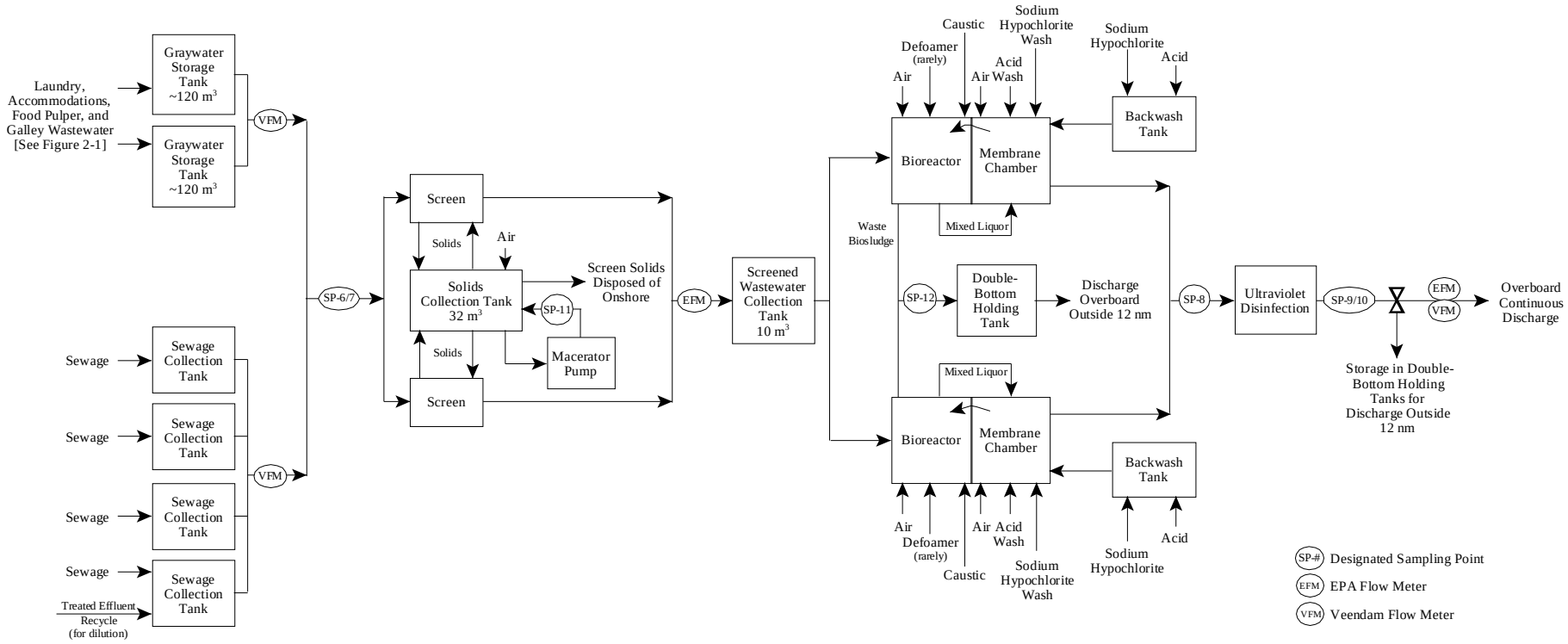

Figure 2-2. Zenon Treatment System, Holland America Veendam

Simplified diagram of the Holland America Veendam Zenon membrane bioreactor treatment system. See Table 2-1 for a list of wastewater streams in each wastewater source, and Figure 2-1 for their collection and conveyance to the treatment system.

3.0 SAMPLE COLLECTION AND ANALYSIS METHODOLOGY

This section describes the sample collection and analysis methods and deviations from the ship-specific Sampling and Analysis Plan for Holland America Veendam (Veendam SAP; Appendix E). A more detailed explanation of the sampling methodologies, analytes and analytical methods, sampling frequency and duration, schedule, and logistics that were followed during sampling onboard the Veendam can be found in Section 3.0 of the Veendam SAP.

3.1 Pre-Sampling Activities

EPA performed an engineering ship visit to the Veednam on March 27, 2004. The Veendam SAP was prepared based on information collected during that ship visit and from subsequent follow-up communication with Holland America personnel. One week prior to the sampling episode, personnel conducted sampling setup activities onboard the Veendam, including loading sampling equipment and the onboard laboratory, inspecting the installed sampling ports, installing the strap-on ultrasonic flow meters, and installing and programming the automatic sampling machines.

3.2 Sample Collection and Analysis Methodology

In general, graywater sources and wastewater treatment residual samples were taken for one 24-hour period, while samples of the influent to and effluent from the treatment system were taken for five consecutive 24-hour periods (see Tables 2-1 and 2-2). Various sample collection methods (described in Table 3-1) were used depending on the waste stream and analyte (see Table 3-2). Most samples were composited over each 24-hour sampling period or were single grab samples in a 24-hour period. However, multiple (1 to 4) grab samples per 24-hour period were collected for pathogen indicator analyses because these samples must be analyzed within 6 hours of collection (see Table 3-2). Table 3-3 describes the analyte groups and lists the analytical methods used.

Each time a grab or grab composite sample was taken, another separate sample was placed in a separate container to perform field measurements of pH, temperature, conductivity, salinity, turbidity, sulfide, and free and total chlorine on board. Temperature and pH were measured immediately at the sampling point, and the remaining parameters were measured at the sample staging area on board. See Table 3-4 for equipment used for these measurements. Field measurements are used primarily to determine sample preservation requirements. Samples (other than those used for field measurements) were preserved in accordance with procedures described in the Veendam SAP (Appendix E), with exceptions as noted in Section 3.6 and Table 3-5. Note that while Alaska and Federal regulations for cruise ship discharges include standards for total residual chlorine, the equipment used to measure residual chlorine onboard was not suitable for measuring low levels of chlorine (detection limit of 20 µg/L compared to a standard of 10 µg/L) and was subject to various interferences, such as from oxidized forms of manganese. Accordingly, the field measurements collected during this sampling episode should not be used to assess compliance with cruise ship discharge standards.

Flow data were collected from both the strap-on flow meters installed by the sampling team and the pre-existing Veendam in-line flow meters. See Section 2.4 for descriptions of the flow meter locations and Figures 2-1 and 2-2 for their locations. The strap-on flow meters were programmed to record the instantaneous flow rate (m^3/min) and total cumulative flow (m^3) every five minutes. Total cumulative flow (m^3) from the in-line flow meters was manually recorded approximately every four hours during the sampling episode.

3.3 Converting Solids Mass Units to Volume Units

The food pulper, screening solids, and waste biosludge samples had high solids contents; therefore, the results listed below were reported by the laboratories in mass units.

- Food pulper: volatile and semivolatile organics;
- Screening solids: classical pollutants (except total and available cyanide), total mercury, and volatile and semivolatile organics; and

- Waste biosludge: classical pollutants (except total and available cyanide), total mercury, and volatile and semivolatile organics.

Solids contents for these samples ranged from 1.3% to 2.9%. To allow for direct comparison of these results to those of other wastewater samples, mass units for these samples were converted to volume units using the following equation and assuming a sample density of 1:

Amount (mass units) * (% solids/100) = Amount (volume units)

All data in this report pertaining to food pulper, screening solids, and waste biosludge samples are reported in volume units. The laboratory data packages, which are included in the Cruise Ship Rulemaking Record and available upon request, contain the original mass units results reported by the laboratories. Note that the analytical results for the incinerator ash sample were also reported in mass units. However, the incinerator ash results were not converted because the sample was 97.1% solids.

3.4 Quality Assurance/Quality Control

Duplicate samples were collected for quality assurance and quality control. Results for duplicate samples were averaged. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling. Other field quality control samples prepared for this sampling episode include a trip blank and an equipment blank, which are discussed in Sections 5.2.1 and 5.2.2, respectively.

3.5 Interview with the Ship's Crew

The ship's crew was interviewed to obtain information regarding activities that impact wastewater generation. See Appendix C for details on these interviews and Section 4.2 for a summary.

3.6 Deviations from the Sampling and Analysis Plan

The sampling episode proceeded as specified in the Veendam SAP with the deviations described in Table 3-5.

Table 3-1

Sample Collection Method Descriptions, Holland America Veendam

Sample Collection Method	Description
Composite by Flow	Flow-weighted composite samples were collected using an automatic sampling machine interfaced with an installed strap-on ultrasonic flow meter (see Section 2.4). The flow meter signaled the automatic sampling machine to collect a 250-mL sample aliquot each time a fixed quantity of wastewater passed through the wastewater pipe. The number of composite sample aliquots collected per 24-hour sampling period ranged from approximately 75 to 150, depending on the total volume of sample required for planned analyses each sampling day. Sample aliquots were collected into a 10-L sample composite jar stored within the sampling machine. At the end of each 24-hour sampling period, the sample composite jar(s) were mixed and poured into individual sample bottles for analysis. Samples collected using the composite-by-flow method best represent a waste stream flowing through a pipe.
Composite by Time	Time-weighted composite samples were collected using an automatic sampling machine programmed to collect 250-mL sample aliquots at fixed time intervals. The programmed time interval differed by sampling point (see Table 3-2). The number of composite sample aliquots collected per 24-hour sampling period ranged from approximately 75 to 150, depending on the total volume of sample required for planned analyses. Sample aliquots were collected into a 10-L sample composite jar stored within the sampling machine. At the end of the 24-hour sampling period, the sample composite jar(s) were mixed and poured into individual sample bottles for analysis. The composite-by-time method was used when the composite-by-flow method was not feasible.
Grab	Grab samples were discrete samples collected directly into the sample bottles from the sample tap or through Teflon® tubing connected to the sample tap. Note that samples for pathogen indicator analyses were collected as grab samples (as opposed to composite samples) because they must be analyzed within a 6-hour holding time.
Grab Composite	Samples (1 to 4 per 24-hour sampling period) were manually collected as grab samples but composited either in the field or at the laboratory for a single analysis. The grab composite method was used when the composite-by-flow or composite-by-time methods were not appropriate. **Volatile organics** - grab samples were collected directly into sample vials, which were filled completely to avoid loss of target analytes by volatilization. Grab samples for each 24-hour period for analysis of volatile organics were composited by the laboratory for a single analysis. **Total and available cyanide** - grab samples were chemically preserved as soon as possible to minimize sample interferences. The preserved total and available cyanide grab samples for each 24-hour period were composited onboard by the sampling team for a single analysis. **Hexane extractable material/silica-gel treated hexane extractable material (HEM/SGT-HEM)** - grab samples were collected directly into sample containers to avoid loss of HEM/SGT-HEM that might adhere to the interior of any interim sampling container (e.g., sample composite jar). See Table 3-5, HEM/SGT-HEM sample collection, for a description of the HEM/SGT-HEM grab composite sampling method, resulting in a single analysis for each 24-hour sampling period.

Table 3-2

Sample Collection Methods and Analyte Groups Tested by Sampling Point, Holland America Veendam

Wastewater Name	Sampling Point #(a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Laundry	SP-1/2	**Composite by time** Automatic sampling machine was programmed to collect 250-mL sample aliquots at three-minute time intervals. The sampling machine successfully collected sample aliquots only during the relatively few intervals during the 24-hour sampling period (2300 on 6/23/04 to 2300 on 6/24/04) when the laundry wastewater was generated and flowed through the inlet pipe to the holding tank, thereby more closely approximating a flow-weighted composite sample.	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics Dioxins and furans	1 (Day 4)
		Grab composite Collection times of the four subsamples in the composite can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen indicators	
Accommodations	SP-3	**Composite by time** Automatic sampling machine was programmed to collect 250-mL sample aliquots at three-minute time intervals. The sampling machine successfully collected sample aliquots only during the relatively few intervals during the 24-hour sampling period (0600 on 6/23/04 to 0600 on 6/24/04) when the accommodations wastewater holding tank discharge pump turned on, thereby more closely approximating a flow-weighted composite sample.	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics	1 (Day 4)
		Grab One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen indicators Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	

(a) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.
(e) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day (Day 1).

Table 3-2 (Continued)

Wastewater Name	Sampling Point #(a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Food Pulper	SP-4	**Grab composite** To characterize the food pulper wastewater that is conveyed to the wastewater treatment system, grab samples were collected from the tank just prior to discharging the food pulper wastewater holding tank to the wastewater treatment system (i.e., just prior to 0800, 1500, and 2000). See Appendix A-3 for the exact collection times for the three subsamples in the composite.	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II - HEM/SGT-HEM - Total and available cyanide Total and dissolved metals Volatile and semivolatile organics	1 (Day 3)
		Grab Grab food pulper samples were collected from the same location as described above. Two grab samples were taken. Results presented in Table 4-1 are an average. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Galley	SP-5	**Composite by time** Automatic sampling machine was programmed to collect sample aliquots at 20-minute time intervals during the 24-hour sampling period (1200 on 6/21/04 to 1200 on 6/22/04).	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics Pesticides	1 (Day 2)
		Grab composite Collection times of the four subsamples in the composite can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen indicators	

(a) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.
(e) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day (Day 1).

Table 3-2 (Continued)

Wastewater Name	Sampling Point #(a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Influent to Zenon Treatment System	SP-6/7	**Composite by Flow** Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics Pesticides Polychlorinated biphenyls	5
		Grab Composite The collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab The number of grab samples taken per sampling day were as follows: 4, 3, 2, 3, 3. Results presented in Table 4-2 are an average for each sampling day. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Influent to UV Disinfection part of Zenon Treatment System	SP-8	**Grab** The number of grab samples taken per sampling day were as follows: 4, 3, 2, 3, 3. Results presented in Table 4-3 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	5

(a) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.
(e) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day (Day 1).

Table 3-2 (Continued)

Wastewater Name	Sampling Point #(a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Effluent from Zenon Treatment System	SP-9/10	**Composite by Flow** Twenty-four-hour sampling periods began at 0600 each day.	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II Total and dissolved metals Semivolatile organics	5
		Grab Composite Collection times of the four subsamples in the composites each day can be found in Appendix A-3.	Classical pollutants: - HEM/SGT-HEM - Total and available cyanide Volatile organics	
		Grab The number of grab samples taken per sampling day were as follows: 4, 3, 2, 3, 3. Results presented in Table 4-4 are an average for each sampling day (calculation used detection limits for nondetected results). Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Screening Solids	SP-11	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II - Total and available cyanide Total metals Volatile and semivolatile organics	1 (Day 1)
Waste Biosludge	SP-12	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II - Total and available cyanide Total metals Volatile and semivolatile organics	1 (Day 2)

(a) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.
(e) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day (Day 1).

Table 3-2 (Continued)

Wastewater Name	Sampling Point #(a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Incinerator Ash	SP-13/14	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Total metals Semivolatile organics Dioxins and furans	1 (Day 1)
Source Water	SP-15	**Grab** One grab sample was taken per sampling day for pathogen indicator analyses, while one grab sample was taken for all other analytes. Appendix A-3 shows the collection times.	Pathogen indicators Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II - Total and available cyanide Total and dissolved metals Volatile and semivolatile organics	5 / 1 (e)
Trip Blank	SP-16	**Grab** One grab sample was taken. High performance liquid chromatography (HPLC) water was poured directly into sample vials in the contractor's Chantilly, VA sampling room and shipped to the Veendam. The trip blank was shipped back (unopened) to the laboratory along with the collected samples.	Volatile organics	1
Equipment Blank	SP-17	**Grab** One grab sample was taken. The equipment blank consisted of HPLC water pumped through the automatic sampling machine and tubing and directly into sample bottles.	Total and dissolved metals Semivolatile organics	1

(a) See Figures 2-1 and 2-2 for simplified diagrams of the Veendam graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-3 and 5-4 for details on duplicate sampling.
(c) See Table 3-1 for descriptions of sample collection methods.
(d) See Table 3-3 for additional information regarding analytes tested and analytical methods used.
(e) Source water samples for pathogen indicator analyses were collected for five days. Source water samples for analysis of all other analytes were collected for one day (Day 1).

Table 3-3

Analytes and Analytical Methods, Holland America Veendam

Analyte Group	Analytes	Analytical Method Number
Pathogen Indicators	*E. Coli*	EPA 9223B
	Enterococci	ASTM D6503-99
	Fecal Coliform	EPA 9222D
Classical Pollutants	Biochemical Oxygen Demand (BOD_5)	EPA 405.1
	Settleable residue (SS)	EPA 160.5
	Group I: - Total Suspended Solids (TSS) - Total Dissolved Solids (TDS) - Sulfate - Chloride - Alkalinity	 EPA 160.2 EPA 160.1 EPA 375.4 EPA 325.3 EPA 310.1
	Group II: - Total Organic Carbon (TOC) - Chemical Oxygen Demand (COD) - Ammonia as Nitrogen - Nitrate/Nitrite as Nitrogen - Total Kjeldahl Nitrogen (TKN) - Total Phosphorus	 EPA 415.1 HACH 8000 EPA 350.1 EPA 353.2, EPA 1685 (“solids” samples) EPA 351.3, EPA 1687 (“solids” samples) EPA 365.1
	Oil and grease measured as hexane extractable material and petroleum hydrocarbons measured as silica-gel treated hexane extractable material (HEM/SGT-HEM)	EPA 1664
	Cyanide - Total cyanide - Available cyanide	 EPA 335.3 EPA 1677
	Hardness	SM 2340B
Total and Dissolved Metals	See Appendix A-2 for complete list of total and dissolved metals analyzed.	EPA 200.7, EPA 200.8 (selenium and thallium), EPA 245.1 (mercury, “liquid” samples), EPA 245.5 (mercury, “solids” samples)
Volatile and Semivolatile Organics	See Appendix A-2 for complete list of volatile and semivolatile organics analyzed.	EPA 624 EPA 625
Pesticides	See Appendix A-2 for complete list of organohalide and organophosphorus pesticides analyzed.	EPA 1656A EPA 1657A
Polychlorinated Biphenyls (PCBs)	See Appendix A-2 for complete list of PCBs analyzed.	EPA 1668A
Dioxins and Furans	See Appendix A-2 for complete list of dioxins and furans analyzed.	EPA 1613B

Table 3-4

Field Measurement Equipment, Holland America Veendam

Parameter	Measured by:
pH	Four-color pH paper
Temperature	Alcohol thermometer
Conductivity and Salinity	Portable conductivity/salinity meter (YSI Model 30)
Turbidity	Pocket turbidimeter (Hach Cat. No. 52600-00)
Sulfide	Colorimeter (Hach DR 890)
Free and Total Chlorine	Pocket colorimeter (Hach Cat. No. 46700-00)

Table 3-5

Deviations from the Sampling and Analysis Plan, Holland America Veendam

Deviation	Description
Pathogen Indicators Sample Collection	The number of grab samples collected for pathogen indicator analyses was reduced from 97 described in Table 3-1 of the Veendam SAP to 66 (including QC samples), primarily due to capacity limitations of the onboard laboratory. The actual number of pathogen indicators samples analyzed is indicated in the presentation of analytical results in Section 4.1 and in Appendix A-1 of this document. The sampling team collected and analyzed as many pathogen indicators samples as was feasible, with an emphasis on wastewater treatment samples. Although diminished, the resulting pathogen indicators data set is adequate for EPA's needs for this program.
Pathogen Indicators Laboratory Duplicates	For 5% of the pathogen indicators samples, duplicate 100-mL sample volumes were taken with the intention that the laboratory would composite the 100-mL sample volumes and then analyze duplicate samples from each composite sample to evaluate laboratory precision (i.e., laboratory duplicates). However, the laboratory did not prepare composites, but instead analyzed each of the 100-mL sample volumes individually. Accordingly, the results obtained from these analyses are field duplicate samples, not laboratory duplicates, and are presented and handled as such in this report. See Section 5.2.3 and Table 5-4 for details on duplicate sampling for pathogen indicators.
Pathogen Indicators Field Duplicate Samples	The sampling team planned to collect field duplicate samples for pathogen indicators at only the effluent from treatment (SP-9/10). However, the laboratory mistakenly analyzed additional pathogen indicators sample volume that was collected as a contingency at the influent to treatment (SP-6/7) and the influent to UV disinfection (SP-8). Contingency sample volume was collected using the same methodology as the original sample. Accordingly, the results obtained from these analyses are field duplicates and are presented and handled as such in this report. The duplicate sample pairs include samples 65224/65310 and 65259/65304. See Section 5.2.3 and Table 5-4 for details on duplicate sampling for pathogen indicators.
HEM/SGT-HEM Sample Collection	HEM/SGT-HEM grab samples were not analyzed separately at the laboratory. Instead, the sampling team developed a methodology to composite the HEM/SGT-HEM grab samples onboard for a single analysis per sampling point per day, rather than up to 4 separate sample analyses per sampling point per day. For example, at sampling points where a total of four grab samples were collected during a 24-hour sampling period, the sampling team filled approximately one-fourth (250 mL) of the sample containers when they collected each grab sample, resulting in 1-liter of sample in each container at the end of each sampling period. This deviation significantly reduced sample handling and storage requirements, which were limited onboard the ship, while still producing a HEM/SGT-HEM data set adequate for EPA's needs for this program.
HEM/SGT-HEM Field Duplicate Samples	Field duplicate samples for HEM/SGT-HEM analysis were not planned. However, due to sampler error on the sample bottle labels, the laboratory mistakenly analyzed additional HEM/SGT-HEM sample volume that was collected as a contingency at certain sampling points/days. Contingency sample volume was collected using the same methodology as the original sample. Accordingly, the results obtained from these analyses are field duplicates and are presented and handled as such in this report. The duplicate sample pairs include samples 65227/65228, 65231/65232, 65269/65270, 65273/65274, and 65277/65278. See Section 5.2.3 and Table 5-4 for details on duplicate sampling for HEM/SGT-HEM.
Hardness	The method was revised to determine hardness from a field titration measurement to a calculation determined using metals analysis results for calcium and magnesium. The calculation approach is considered to be more accurate than the field titration approach (see Method 2340B in *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, 1998).

Table 3-5 (Continued)

Deviation	Description
Laundry Wastewater (SP-1/2)	The sampling team was unable to integrate the strap-on flow meter with the automatic sampling machine to collect a flow-weighted composite sample at this sampling point. Although the sampling set-up team was able to successfully install a strap-on flow meter at the discharge from the laundry wastewater holding tank, the sampling tap was not installed at this same position due to commingling of other graywater sources caused by backflow from the graywater main common line. (Note: the flow meter was set to ignore negative flow through the pipe.) Instead, the ship's crew installed the sampling tap on the gravity drain inlet pipe to the laundry wastewater holding tank. The strap-on flow meter could not be used to initiate collection of flow-weighted composite samples because flow measurements at the discharge pipe consistently triggered sample collection when no wastewater was flowing in the inlet pipe. As an alternative sampling methodology, the automatic sampling machine was programmed to collect a time-weighted composite sample as described in Table 3-2. EPA concluded that the collected samples were representative of laundry wastewater as generated onboard the Veendam.
Accommodations Wastewater (SP-3), Composite Samples	The strap-on flow meter set-up and calibration procedure was unsuccessful at the accommodations wastewater sampling point (the outlet pipe from the accommodations wastewater holding tank), most likely due to poor pipe flow conditions such as pipe scaling or extreme aeration. As a result, flow data could not be collected at this sampling point. In addition, the flow meter could not be used to initiate collection of flow-weighted composite samples at SP-3 as described in the Veendam SAP. As an alternative sampling methodology, the automatic sampling machine was programmed to collect a time-weighted composite sample as described in Table 3-2. EPA concluded that the collected samples were representative of accommodations wastewater as generated onboard the Veendam.
Accommodations Wastewater (SP-3), Grab Samples	The sampling team successfully collected only one of the four planned grab samples at SP-3 due to the inability to coordinate sample collection times with adequate wastewater volumes in the accommodations holding tank. After collecting the first sample, samplers unsuccessfully attempted to collect grab samples by manually operating the duty pump approximately once per hour throughout the 24-hour sampling period. EPA concluded that the single grab sample represented an instantaneous snapshot of accommodations wastewater as generated onboard the Veendam.
Effluent From Treatment (SP-9/10)	The sampling team was unable to use the input/output on the existing flow meter at SP-9/SP-10 to collect flow-weighted composite samples at this sampling point because it would modify existing flow meter outputs. As an alternative sampling methodology, the sampling team installed a strap-on flow meter at this location to collect flow characterization data and to control automatic composite sample collection. Comparison of the instantaneous flow measurements for the existing and strap-on flow meters throughout the sampling episode demonstrated excellent agreement. This deviation had no impact on the representativeness of the collected samples. Composite by flow sampling at SP-9/SP-10 was suspended on Day 3 from 0645 to 2120 because overboard discharge was restricted while the ship cruised Glacier Bay. (The flow meter that controlled composite by flow sample collection was located on the overboard discharge pipe, but during this time the effluent was diverted to double-bottom holding tanks.) However, grab and grab composite samples were taken during this period.
Waste Biosludge (SP-12)	The sampling team was unable to collect waste biosludge samples during overboard discharge because of the inability to install a functional sample tap on the vertical gravity flow discharge piping. As an alternative sampling methodology, the sampling team collected a one-time grab sample of waste biosludge before it was sent to and held in the double-bottom holding tank for eventual discharge 12 nm from shore. Accordingly, the collected samples characterize waste biosludge as generated rather than as discharged.

Table 3-5 (Continued)

Deviation	Description
Cyanide Sample Preservation	The supply of lead carbonate preservative was consumed after the second sampling day. Therefore, for sampling Days 3 through 5, samples were not treated to remove sulfide prior to receipt by the laboratory. See the memorandum *Issues Associated with Results for Total Cyanide Versus Available Cyanide*, included in Appendix D, for further information regarding the impact of sulfide interferences on cyanide results.
Volatile Organics Preservation	Free chlorine was detected in presampling field tests at all sampling points. Based on these results, the sampling team prepreserved all volatile organics sample vials with sodium thiosulfate rather than waiting to determine preservation requirements based on the free chlorine field test results. Free chlorine was generally detected in grab samples collected throughout the sampling episode. (Sample vials were also prepreserved with hydrochloric acid to control biological activity as discussed in the Veendam SAP.)
Analytical Methods	EPA-contracted laboratories substituted comparable approved EPA analytical methods for analysis of certain analytes. Table 3-3 lists the actual analytical methods used by the laboratories. Note that while the Veendam SAP correctly listed EPA Methods 624 and 625 as the planned methods for analyzing volatile and semivolatile organics, respectively, Appendix E of the Veendam SAP mistakenly listed the target analytes for EPA Methods 1624 and 1625. Appendix A-2 of this report presents the actual list of target volatile and semivolatile organics.
Sampling Schedule	The sampling team adjusted the sampling schedule in Appendix C of the Veendam SAP to accommodate sampling logistics and ship operations. Refer to Appendix A-3 of this report for actual samples collected and sample collection dates/times.
Ship Overview Inaccuracies	Certain information in Section 3.0, Ship Overview, of the Veendam SAP, was inaccurate or incomplete: • *Food pulper wastewater*. Food pulper wastewater is not pretreated by grease traps but conveyed to the treatment system without pretreatment. • *Wastewater treatment chemical addition.* Operators add defoamer (rarely) and caustic to the bioreactor as needed; nitrogen (nutrient) addition is no longer used and has been disabled. Operators add citric acid and sodium hypochlorite to the membrane backwash tank on alternate days. • *Ultrafiltration membrane cleaning cycle.* See Section 2.2 of this report for a description of the membrane cleaning cycle. • *Wastewater treatment residuals.* See Section 2.2 of this report for additional information regarding wastewater treatment sludge generation, handling, and discharge/disposal.

4.0 RESULTS AND DISCUSSION

This section presents the data collected during this sampling episode. Section 4.1 presents the analytical results and discussion; Section 4.2 presents interview results for activities that impact wastewater generation; and Section 4.3 presents flow data and analysis. Analytical results for field measurements performed onboard are presented in Appendix A-3. Note that anomalous analytical results were obtained for available and total cyanide; these data have not been excluded from the data set, but the results are presented in and discussed in Section 5.1.1 (in the data quality section of this report) and not in the current section.

4.1 Laboratory Analytical Results and Discussion

4.1.1 Graywater

Table 4-1 presents analytical results for laundry, accommodations, food pulper, and galley wastewaters, which were sampled for one 24-hour period. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influent to treatment system, or effluent from treatment system) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Of the 295 analytes tested for in the graywater sources, 67 were detected in these waste streams. Twenty-one of these 67 analytes were also detected at some level in the equipment blank (flagged by an "e" in Table 4-1; see Table 5-2 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of possible contamination from sampling equipment in a future analysis. Thirty-two of these 67 detected analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-1; see Table 4-8 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

Chart 1 presents the number of analytes detected in each graywater source.

Chart 1. Number of Analytes Detected in Graywater Sources

Analyte Group (a)	Number of Analytes Detected			
	Laundry	Accommodations	Food Pulper	Galley
Pathogen Indicators	0	3	3	3
Classical Pollutants	14	14	15	13
Total and Dissolved Metals	29	33	42	33
Volatile and Semivolatile Organics	1	4	2	2
Total	**44**	**54**	**62**	**51**

(a) See Table 3-3 for information on analyte groups.

Chart 2 presents the number of analytes that were detected in each graywater source at the highest concentration. For example, the highest detected concentrations for two of the pathogen indicators were found in the food pulper wastewater, while the highest detected concentration for the third indicator was found in the accommodations wastewater. Note that a graywater source that has the highest concentration of an analyte will not necessarily contribute the greatest amount of that analyte to the wastewater treatment system. The total amount of an analyte contributed by a particular graywater source also will depend on that source's volume compared to the volumes of the other sources. Flow (and thus volume) information was not able to be collected for all graywater sources (see Table 2-1).

Chart 2. Number of Analytes Detected at Highest Concentration in Graywater

Analyte Group (a)	Number of Analytes Detected in Graywater	Number of Analytes Detected at the Highest Concentration			
		Laundry	Accommodations	Food Pulper	Galley
Pathogen Indicators	3	0	1	2	0
Classical Pollutants	16	1	0	15	0
Total and Dissolved Metals	44	4	8	32	0
Volatile and Semivolatile Organics	4	0	2	2	0
Total	**67**	**5**	**11**	**51**	**0**

(a) See Table 3-3 for information on analyte groups.

Food pulper wastewater contained both the greatest number of detected analytes (62) and the greatest number of analytes detected at the highest concentration (51 out of 67

detected analytes). Food pulper wastewater had the highest concentrations of *E. coli* and enterococci, almost all classical pollutants (including hexane extractable material (HEM) and silica-gel treated hexane extractable material (SGT-HEM), nutrients, and solids), and most metals.

Accommodations wastewater contained a total of 54 analytes and showed the highest concentration among the wastewaters for 11 of the analytes, including fecal coliform, tetrachloroethene, trichloroethene, and 8 metals.

Laundry wastewater contained a total of 44 analytes and showed the highest concentration for 5 analytes, including alkalinity and several dissolved metals. Laundry wastewater was the only graywater source that was analyzed for dioxins and furans because this was the most likely possible source of these analytes; none were detected.

Galley wastewater contained a total of 51 analytes but did not have the highest concentration of any of the analytes among graywater sources. Galley wastewater did, however, show the second highest concentration for several analytes commonly used to measure wastewater strength: al1 3 pathogen indicators, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), HEM/SGT-HEM, and total suspended solids (TSS). The galley wastewater was sampled before pretreatment (grease trap), which would reduce HEM/SGT-HEM concentrations prior to entering the wastewater treatment system. Galley wastewater was the only graywater source that was analyzed for pesticides because this was the most likely possible source; none were detected.

4.1.2 Influent to Treatment System

Table 4-2 presents analytical results for the influent to the treatment system, which was sampled for five consecutive 24-hour sampling periods. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influent to treatment system, or effluent from treatment system) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Pathogen Indicators and Classical Pollutants

All 3 pathogen indicators and all 16 classical pollutants were detected in the influent to treatment samples. One of these 19 analytes (hardness) was also detected at some level in the equipment blank (flagged by an "e" in Table 4-2; see Table 5-2 for equipment blank results), meaning that the sampling equipment may have contributed some or all of this analyte to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Eight of these detected analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-2; see Table 4-8 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

Wastewater conservation practices used onboard, such as use of vacuum toilets, result in highly concentrated wastewater. Chart 3 compares the influent to the Veendam treatment system to typical domestic wastewater for selected pathogen indicators and classical pollutants. Fecal coliform and enterococci concentrations in the influent to the Veendam treatment system were two or more orders of magnitude greater than in typical untreated domestic wastewater. Key analytes commonly used to assess wastewater strength, such as BOD_5, TSS, and COD, were detected at concentrations two or more times greater than typical domestic wastewater.

Chart 3. Comparison of Influent to Veendam Treatment System to Untreated Domestic Wastewater

Analyte	Influent to Veendam Treatment System	Untreated Domestic Wastewater (a)
Enterococci	10^5 to 10^6 MPN/100 mL	10^2 to 10^3 number/100 mL
Fecal Coliform	10^6 to 10^7 CFU/100 mL	10^4 to 10^5 number/100 mL
Ammonia	60 to 84 mg/L	12 to 50 mg/L
Biochemical Oxygen Demand (BOD_5)	481 to 786 mg/L	110 to 400 mg/L
Chemical Oxygen Demand (COD)	799 to 2,040 mg/L	250 to 1,000 mg/L
Nitrate/Nitrite	ND to 0.07 mg/L	0 mg/L
Oil and Grease	41 to 164 mg/L	50 to 150 mg/L
Total Phosphorus	10 to 20 mg/L	4 to 15 mg/L
Total Suspended Solids (TSS)	473 to 805 mg/L	100 to 350 mg/L

(a) Source: Metcalf & Eddy, *Wastewater Engineering*, Third Edition, 1991.

Total and Dissolved Metals

Of the 36 metal analytes detected in the influent to treatment samples, 27 were detected in every influent to treatment sample (Table 4-2). Twenty of these 36 analytes were detected at some level in the equipment blank (flagged by an "e" in Table 4-2; see Table 5-2 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Twenty-four of these detected analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-2; see Table 4-8 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

The 10 metal analytes detected at the highest concentrations were: total and dissolved calcium, total and dissolved magnesium, total and dissolved iron, total and dissolved sodium, total aluminum, and total zinc. Total and dissolved copper, nickel, selenium, and zinc, and dissolved mercury are priority pollutant metals (designated by EPA in 40 CFR Part 423, Appendix A) that were detected in every influent to treatment sample. Some metals may result from contact with carbon and stainless steel pipes and tanks in the ship.

Volatile and Semivolatile Organics, Pesticides, PCBs

Among the 365 target analytes for volatile and semivolatile organics, pesticides, and polychlorinated biphenyls (PCBs), only 9 were detected in any Veendam influent to treatment samples: 2 semivolatile organics, 2 volatile organics, and 5 PCBs (Table 4-2). Many of these analytes were detected at concentrations close to their detection limits. Neither of the 2 detected semivolatile organics were detected in the equipment blank (see Table 5-2 for equipment blank results; volatile organics and PCBs were not analyzed for in the equipment blank). None of the 4 detected volatile or semivolatile analytes were detected in the source water (see Table 4-8 for source water results; PCBs were not analyzed for in source water).

The two semivolatile organics detected in the influent to treatment were: bis(2-ethylhexyl)phthalate and phenol. Bis(2-ethylhexyl)phthalate is a plasticizer (a chemical added to plastics to make them flexible) and is commonly detected in environmental samples (ATSDR, 2002). Cruise ships use a wide variety of plastic products (e.g., floor tiles, shower curtains, hoses, packaging materials and containers, PVC piping) that may result in the presence of bis(2-ethylhexyl)phthalate in the influent to treatment. Other possible sources include tubing and other plastic materials used by the analytical laboratory.

Phenol is both man-made and produced naturally. It is found in human wastes (urine). It is also found in some foods (smoked summer sausage, fried chicken, mountain cheese, some species of fish). Man-made sources include the use of phenol as a slimicide, as a disinfectant, and in medicinal preparations such as ointments, ear and nose drops, and antiseptic wipes. (ATSDR, 1998) All of these are possible sources for the presence of phenol in cruise ship wastewater.

The two volatile analytes detected in the influent to treatment were tetrachloroethene and trichloroethene. Tetrachloroethene is a solvent used in metal cleaning and dry cleaning (EPA, 2001). The Veendam has a dry cleaning facility, but all tetrachloroethene wastes are collected for shoreside waste disposal. According to the ship's crew, noncontact cooling water (cooling water that does not come into contact with dry cleaning solvent) is routed to the accommodations wastewater system. Tetrachloroethene was detected in accommodations wastewater; however, the average tetrachloroethene concentration in the influent to wastewater treatment was almost 20 times greater than the tetrachloroethene concentration detected in accommodations wastewater. Interviews with the ship's crew did not identify any other sources of tetrachloroethene aboard the Veendam.

Trichloroethene is a solvent used in metal degreasing, metal finishing, paint and ink formulation, and electrical/electronic components (EPA, 2001). The Veendam print shop is equipped with a sink used for hand washing and diluting chemicals. The sink drains to the accommodations wastewater system. Trichloroethene was detected in the accommodations wastewater and in the influent to treatment at similar concentrations.

No pesticides were detected in the influent to the Veendam wastewater treatment system.

Five PCB congeners and co-eluting congener groups were detected in the influent to the wastewater treatment system: PCB-6, PCB-11, PCB-16, PCB-21+PCB-33, and PCB-153+PCB-168. In addition, the laboratory reported values for total dichloro-biphenyls and total PCBs. PCBs were generally detected at very low concentrations, less than one part per billion, just above the reported detection limit. The only exception was PCB-11 (3,3'-dichlorobiphenyl), which was detected at a concentration of twice the detection limit. None of the detected PCBs were among the 12 "toxic" PCBs identified by the World Health Organization. (Note that PCBs were not analyzed for in the source water.)

4.1.3 Influent to the Ultraviolet (UV) Disinfection Part of the Treatment System

Table 4-3 presents pathogen indicator results for the influent to UV disinfection part of the Veendam's wastewater treatment system. Grab samples for pathogen indicator analyses were collected at this sampling point for five consecutive 24-hour sampling periods. Pathogen indicators, which were generally in the millions at the influent to the treatment system (see Table 4-2), were reduced to less than 100 after the bioreactor and membrane filter (i.e., before the UV disinfection step). Data for pathogen indicators in the final effluent (i.e., after the UV disinfection step) are presented in the next section.

4.1.4 Effluent from the Treatment System

Table 4-4 presents analytical results for the effluent from the treatment system, which was sampled for five consecutive 24-hour sampling periods. Only those analytes detected at least once in any of the wastewater samples (i.e., graywater sources, influent to treatment system, or effluent from treatment system) are included in this table. Appendices A-1 and A-2 present results for both detected and nondetected analytes.

Pathogen Indicators and Classical Pollutants

A total of 15 grab samples were collected for analysis of the three pathogen indicators over the five 24-hour sampling periods (results and collection times for each grab sample are presented in Appendix A-1). Pathogen indicators generally were not detected in the effluent from the treatment system; the exceptions to this were 2 grab samples, both on Day 4, with enterococci detected at concentrations close to the detection limit.

Thirteen of the 16 classical pollutants were detected in effluent from treatment system; 3 classical pollutants (HEM, SGT-HEM, and TSS) were not detected in any effluent samples. One of the 13 detected classical analytes–hardness–was also detected at some level in the equipment blank (flagged by an "e" in Table 4-4; see Table 5-2 for equipment blank results), meaning that the sampling equipment may have contributed some or all of this analyte to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Eight of these detected analytes were also detected at some level in the potable water used as source water for all graywater and sewage systems (flagged by an "s" in Table 4-4; see Table 4-8 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

Chart 4 shows that classical pollutant concentrations in the effluent from the Veendam treatment system are lower than EPA's standards for secondary treatment.

Chart 4. Classical Pollutant Comparison of Effluent from Veendam Treatment System to Secondary Treatment Standards

Classical Pollutant	Average Effluent from Veendam Treatment System	Secondary Treatment Standards (a)
Biochemical Oxygen Demand (BOD_5)	<3.20 mg/L	45 mg/L
Total Suspended Solids (TSS)	ND(5.00) mg/L	45 mg/L

(a) 40 CFR 133.102 Secondary Treatment Regulations, 7-day average.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
ND - Not detected (number in parentheses is detection limit).

Total and Dissolved Metals

Among the 54 total and dissolved metals analytes tested for, 29 were detected in one or more effluent from treatment samples (Table 4-4). Of these 29 detected metals analytes, 23 were detected in every effluent from treatment sample. Seventeen of the 29 detected metal analytes were also detected at some level in the equipment blank (flagged by an "e" in Table 4-4; see Table 5-2 for equipment blank results), meaning that the sampling equipment may have contributed some or all of these analytes to the samples. EPA will consider the impact of possible contamination from equipment in a future analysis. Twenty-three of these detected analytes were also detected at some level in the potable water used as source water for all graywater systems (flagged by an "s" in Table 4-4; see Table 4-8 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples.

The 10 metal analytes detected at the highest concentrations were total and dissolved calcium, magnesium, iron, sodium, and zinc. Total and dissolved copper, nickel, selenium, and zinc, and dissolved mercury are priority pollutant metals (designated by EPA in 40 CFR Part 423, Appendix A) that were detected in every effluent from treatment sample. Some metals may result from contact with carbon steel and stainless steel pipes and tanks in the ship. There are no EPA secondary treatment standards for metals.

Volatile and Semivolatile Organics, Pesticides, PCBs, Dioxins and Furans

Among the 84 target analytes for volatile and semivolatile organics analyzed, only one–tetrachoroethene–was detected in any Veendam effluent samples (Table 4-4). Tetrachloroethene was detected in the Veendam effluent at an average concentration of 33.4 µg/L. On the Veendam, possible sources of tetrachloroethene include metal cleaning and dry cleaning (see Section 4.1.2).

Pesticides, PCBs, and dioxins and furans were not analyzed for in the effluent from the treatment system.

4.1.5 Wastewater Treatment System Performance: Comparison of Influent to Treatment System and Effluent from Treatment System

The Zenon system successfully removed almost all pathogen indicators (>99%; Table 4-5) and most classical pollutants, metals, and organics (Table 4-6).

Pathogen Indicators and Classical Pollutants

Pathogen indicators were substantially removed by the bioreactor and membrane filter (>96%); any remaining pathogen indicators were generally removed by UV disinfection to levels below detection (overall system efficiency >99%, see Table 4-5). Fecal coliform and *E. coli* were not detected in any of the 15 effluent from treatment samples; enterococci was detected at levels close to the detection limit in 2 of the 15 samples.

The treatment system removed almost all biochemical oxygen demand (BOD_5) (>99%), and most chemical oxygen demand (COD) (97%) and total organic carbon (TOC) (93%) (Table 4-6). The system also removed almost all settleable residue and total suspended solids (TSS) (both >99%). Oils and greases (HEM and SGT-HEM) were removed to levels below detection.

The treatment system reduced ammonia, total Kjeldahl nitrogen (TKN, which measures both ammonia and organic forms of nitrogen), and total phosphorus by approximately 75%, while nitrate/nitrite levels remained relatively unchanged (Table 4-6). Nitrogen is likely taken up by the microorganisms in the bioreactor and removed from the system in the waste biosludge. It is unlikely that nitrogen is removed by nitrification (the mechanism of ammonia biodegradation) as nitrification would have resulted in an increase in nitrate/nitrite concentration, but these levels remained relatively unchanged. Phosphorus also is most likely taken up by the microorganisms in the bioreactor as evidenced by elevated total phosphorus concentrations in the waste biosludge (see Section 4.1.6 and Table 4-7).

Total and Dissolved Metals

The total metals analysis measures both the particulate and dissolved forms of metals, while the dissolved metals analysis measures only the dissolved form. The difference between the total and dissolved metals measurements is the particulate metals concentration. Metals were present in both particulate and dissolved forms in the influent to the treatment system (i.e., the total metals concentrations exceeded the dissolved metals concentrations for most metals analytes) (Table 4-2). In comparison, metals were predominantly present in the dissolved form in the effluent from the treatment system (i.e., the total and dissolved metals concentrations were similar in these samples) (Table 4-4). Furthermore, there were elevated metals concentrations in the screening solids and waste biosludge (see Table 4-7). This means that the treatment system is highly efficient in removing particulate metals, as would be expected for membrane filtration (and as supported by >99% removal of settleable residue and TSS, see Table 4-6). The treatment systems removed dissolved metals with an average efficiency of 37% (Table 4-6).

Volatile and Semivolatile Organics, Pesticides, PCBs, Dioxins and Furans

The treatment system was able to remove most of the volatile and semivolatile organic compounds to levels below detection (Table 4-6). Possible removal mechanisms include biological degradation, adsorption onto screening solids and waste biosludge (see Table 4-7), and/or volatilization.

Pesticides were not detected in the influent to treatment and were not analyzed for in the effluent from treatment. While PCBs were detected in the influent to treatment at low levels, they were not analyzed for in the effluent from treatment; EPA has no data regarding the performance of the Zenon treatment system for removing PCBs. Dioxins and furans were not analyzed for in either the influent to or effluent from the treatment system. Dioxins and furans were analyzed for in laundry wastewater, and none were detected.

4.1.6 Screening Solids, Waste Biosludge, and Incinerator Ash

Table 4-7 presents the results for analytes detected in one-time grab samples of screening solids (from two coarse screens at the beginning of the treatment system), waste biosludge (excess biological mass from the treatment system's bioreactor), and incinerator ash (from incineration of trash, including food solids from the food pulper) collected during the sampling episode. Table 4-7 also shows the average influent to treatment analyte concentrations from Table 4-6 for comparison.

Most of the analytes detected in the screening solids and waste biosludge were also detected in the influent to treatment. For many analytes, concentrations in the screening solids and waste biosludge exceeded those in the influent to treatment, suggesting that these analytes are removed from the system in these waste streams. See Section 4.1.5 for a detailed discussion of wastewater treatment system performance.

4.1.7 Source Water

Potable water is used as source water for all ship operations that generate graywater and sewage (e.g., laundry, galley, food pulper, sinks, showers, and toilets). Potable water is produced onboard and bunkered while in port, with each source providing approximately half of the fresh water requirements for the ship. Twelve total metals, 12 dissolved metals, and 8 classical pollutants were detected in the one-time grab sample of potable water collected during this sampling episode (Table 4-8). None of the analytes detected in the source water exceeded Federal drinking water standards (Table 4-8). Five grab samples of source water were collected for pathogen indicators analysis. No pathogen indicators were detected in these samples.

4.2 Summary of Interviews Regarding Activities that Impact Wastewater Generation

The ship's crew was interviewed to obtain information regarding activities that impact wastewater generation (see Appendix C for detailed reports). The ship's crew provided operational, discharge, and wastewater treatment operating logs corresponding to the period of the sampling episode. These documents are included in the Cruise Ship Rulemaking Record and are available upon request.

4.2.1 Wastewater Generation

Galley

The Veendam has two dining rooms and 24-hour room service. Approximately 4,700 meals (breakfast, lunch, dinner, and snacks) are served daily. The ship's two galleys are equipped with six automatic washing machines (dishwashers, glass washer, pot washers). All six washing machines operate in the evening, and only one dishwasher operates in the morning to handle the small number of meals served at that time. Dishes are washed using Solid Power or Solid Metal Pro (high alkaline solid automatic dishmachine detergents). Both detergents contain 50% caustic soda. The impact of the caustic component of the dishwashing detergent is minimal as the pH of the sampled galley wastewater was 6. The Veendam also uses Rinse Dry, an automatic washing machine rinse aid, which contains an ethyleneoxy/propyleneoxy-derivative nonionic surfactant. Material Safety Data Sheets (MSDS) for these products are included in the Cruise Ship Rulemaking Record and are available upon request.

Laundry

The Veendam laundry is operated 24 hours per day processing approximately five loads of towels and two loads of linens daily; most laundry is washed from approximately 2100 to 0200 each day. On change-over days (i.e., when the ship disembarks passengers and embarks new passengers), more loads of linens are washed. The laundry uses cleaning agents provided by Johnson Diversey; MSDS for these cleaning agents are included in the Cruise Ship

Rulemaking Record and are available upon request. Table 4-9 lists the laundry cleaning agents and their ingredients.

Photo Processing

The Veendam has an onboard photo processing lab. All waste photographic chemicals are collected into drums for disposal onshore. The drums are stored in a sump/containment area to catch any spills. Silver-containing chemical wastes are pretreated by a silver recovery unit, which retains the silver within the filter for eventual recovery. The filtrate is collected into a drum and offloaded for disposal as either hazardous or nonhazardous waste depending on the tested silver content. A laboratory sink is used to rinse equipment such as chemical trays. The sink is physically blocked to prohibit discharges to the accommodations system, and collected rinse waters are pumped to the silver recovery unit. The photo lab has no floor drains to ensure spilled chemicals do not enter the drain system.

Print Shop

The Veendam houses a print shop. The print shop sink is used for hand washing and diluting chemicals for use. The sink drains to the accommodations system. Print shop staff indicated they are careful not to overflow chemicals into the sink when diluting chemicals. The shop has no waste pretreatment facilities and no chemicals are stored in the area. Trichloroethene is a component of print ink and may have contributed to detected concentrations in the accommodations and influent to treatment wastewater samples.

Dry Cleaning

The Veendam has a dry cleaning facility. Solvent wastes from the operation are disposed of onshore as hazardous waste. According to the ship's crew, noncontact cooling water (cooling water that does not come into contact with dry cleaning solvent) drains to the forward holding tank that feeds into the accommodations system. Dry cleaning solvent is stored in plastic drums, and all dry cleaning machinery, piping, and solvent drums are located within a

curbed area designed to contain any spills or leaks and prevent them from entering any floor drains. A sink adjacent to the dry cleaning machine is used for hand washing. Squirt bottles containing stain remover chemicals are stored over the sink.

Chemical Storage

The ship has a discrete area that is used only for chemical storage, primarily laundry cleaning agents, general purpose cleaners, and hand cleaners (no waste is stored in this location). There are no sinks present in the chemical storage area. All chemicals are stored on pallets with no containment. According to the ship's crew, there are no floor drains in the storage area. Additional chemicals may be stored in other locations, such as engine room shops, but the sampling team did not tour these areas.

4.2.2 Pesticide, Fungicide, and Rodenticide Use

The Veendam uses Maxforce bait stations (active ingredient fipronil) to monitor the ship for insects. The bait stations are designed to attract insects and to keep floor wash water out. The monitoring stations are used at all times and are usually placed in galleys, bars, garbage rooms, and some cabins. The Veendam uses two types of spray insecticides: Siegebait (active ingredient hydramethylnon) in cracks and crevices of grout and tiles and Cykick (active ingredient cyfluthrin) in other places. Spray insecticides are used only when an infestation is detected, generally less than once per week. No pesticides were detected in Veendam wastewater samples.

The Veendam does not use fungicides or rodenticides onboard. Traps are set up to catch rodents, and these are inspected routinely. Every six months, the ship hires an outside contractor to conduct an inspection, and the ship is issued a derat certificate.

4.3 Flow Data

Strap-on ultrasonic flow meters were used to collect flow measurements and, in some cases, to control automatic composite sample machines on (1) the outlet from the laundry wastewater holding tank, (2) the influent to the wastewater treatment system, and (3) the effluent from the wastewater treatment system (see Section 2.4 and Figures 2-1 and 2-2). The flow meters were programmed to record the instantaneous flow rate (m^3/min) and total flow (m^3) every five minutes. Appendix B-1 presents all flow measurements from the strap-on flow meters.

In addition, flow data were collected from three of the Veendam's in-line flow meters: (1) on the discharge line from sewage collection tanks, (2) on the discharge line from the graywater storage tanks, and (3) on the effluent from the treatment system (i.e., the overboard discharge line for treated effluent) (see Section 2.4 and Figure 2-2). Combined, the in-line flow meters on the sewage and graywater tank discharges represent the flow into the treatment system. Continuous flow readings from the in-line flow meters are not recorded on the Veendam, so total flow (m^3) was manually recorded 3 to 5 times each day. Appendix B-2 presents the recorded in-line flow meter data.

Note that the times that the in-line flow data were recorded did not always correspond to exactly 24 hours (readings for each sampling day ranged from approximately 22 to 26 hours). Calculations were required to convert these daily flow volumes to the corresponding 24-hour flow volume. First, the total daily flow was calculated as the difference between the total flows recorded at the end of each sampling day. For example, the calculated flow for Day 2 for the effluent from the treatment system was 426 m^3 (300,551 m^3 at 0915 on June 22, 2004 minus 300,125 m^3 at 0654 on June 21, 2004). Second, the calculated total daily flow was prorated to a 24-hour flow volume by multiplying by 24 hours and dividing by the actual time interval of the recorded daily flow measurements. For example, the ratio for the daily flow for Day 2 for the effluent from the treatment system was 0.91 (1,440 minutes divided by 1,581 minutes), resulting in a 24-hour flow volume of 388 m^3. Note that the calculated daily

flow rates from the sewage and graywater in-line flow meters were summed to determine the total daily flow rates to the influent to the treatment system.

Flow data analyses presented in this section are based on only those flow data collected during the sampling episode of June 20 through June 25. Appendix B contains all flow data collected while onboard the Veendam from June 18 through 25.

The total daily volume of laundry wastewater, influent to the treatment system, and effluent from the treatment system for each 24-hour sampling period from both the strap-on and in-line flow meters are presented in Figure 4-1. The Veendam discontinued discharge for part of Day 3 of this sampling episode (while it cruised Glacier Bay National Park) and diverted the wastewater to a holding tank for overboard discharge when outside 12 nm of shore, as can be seen by a dip in the total daily effluent discharge on Day 3. The total daily flow from the laundry, influent, and effluent (excluding Day 3) remained relatively constant over the five-day sampling episode, regardless of whether the ship was in port (Days 1, 4, and 5) or at sea (Days 2 and 3).

The daily flow rates measured by the strap-on flow meter at the influent to treatment are approximately half the influent flow rates calculated from the Veendam's in-line flow meters (on the discharge pipes from the sewage collection and graywater storage tanks) and approximately half the flow rates measured at the effluent from treatment. These data indicate that the quantitative flow data recorded by the strap-on flow meter on the influent to the treatment system are suspect. Therefore, subsequent analyses of flow rates for the influent to and effluent from the treatment system are based on flow measurements from the in-line flow meters. (Analyses of laundry flow rates are based on the strap-on flow meter as there was no in-line flow meter at this location.) Qualitative flow data recorded by the strap-on flow meter on the influent to the treatment system (i.e., fluctuations over time), which controlled collection of flow-weighted composite samples at this sampling point (see Tables 3-1 and 3-2), are believed to be accurate based on a comparison of strap-on and in-line flow meter data.

Daily flow rates and flow per capita are presented in Table 4-10. Per capita flow rates were calculated based on 1,820 people (1,300 passengers and 520 crew) onboard during the sampling episode, as reported by the ship's crew. On average, each person generated approximately 62 gallons of untreated sewage and graywater per day during the sampling episode. This volume included approximately 17 gallons of sewage per day and 45 gallons of graywater per day. Thus, sewage constituted approximately 28% of the total flow to the treatment system and graywater constituted approximately 72%. The average discharge from the treatment system was approximately 58 gallons of treated wastewater per person per day.

Figure 4-2 presents the average effluent from treatment flow for each hour interval over the five consecutive 24-hour sampling periods, calculated from data collected via the strap-on flow meter. The effluent from treatment peaks at around 2200 and fluctuates substantially during the hours from 2200 to around 0500, the period when most passengers are not generating sewage or accommodations wastewater, but when other activities that generate graywater, such as laundry and dishwashing (galley), occur.

Table 4-1

Graywater Analytical Results, Holland America Veendam

Analytical results for each graywater source for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Graywater samples were collected for one 24-hour period; see Section 3.2 for the sample collection methodology. Table 2-1 lists the specific wastewater streams in each graywater source, and Figure 2-1 identifies sampling point locations. Certain food pulper wastewater results were converted from mass to volume units; see Section 3.3. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Pathogen Indicators						
E. coli (b)	MPN/100 mL		ND(10.0)	520	1,220,000 [N=2]	77,600
Enterococci (b)	MPN/100 mL		ND(10.0)	510	19,600 [N=2]	750
Fecal Coliform (b)	CFU/100 mL		ND(1,000)	7,730,000	79,500 [N=2]	1,300,000
Classical Pollutants						
Alkalinity (s)	mg/L		130	48.0	ND(10.0)	ND(10.0)
Ammonia as Nitrogen (NH3-N) (s)	mg/L		0.360	1.00	29.0	0.460
Biochemical Oxygen Demand (BOD_5)	mg/L		63.6	391	17,300	1,050
Chemical Oxygen Demand (COD)	mg/L		170	541	51,400	1,490
Chloride (s)	mg/L		10.0	38.0	655	42.0
Hardness (e) (s)	mg/L		8.45	54.3	270	56.9
Hexane Extractable Material (HEM)	mg/L		20.0	52.0	5,010	142
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.100	ND(0.0500)	0.220	ND(0.0500)
Settleable Residue	mL/L		ND(0.110)	2.10	900	1.70
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(6.00)	ND(7.00)	2,240	7.00
Sulfate (s)	mg/L		13.0	17.0	35.0	24.0
Total Dissolved Solids (TDS) (s)	mg/L		222	242	6,050	527

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with one grab sample for laundry, accommodations, and galley, and two grab samples for food pulper for the 24-hour sampling period. Results for the food pulper grab samples are reported as the average, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).

Table 4-1 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		3.00	12.0	166	24.0
Total Organic Carbon (TOC)	mg/L		49.0	144	5,370	250
Total Phosphorus	mg/L		1.00	3.00	46.0	4.00
Total Suspended Solids (TSS)	mg/L		32.0	254	19,800	413
Total and Dissolved Metals						
Aluminum, Total	ug/L		118	745	2,910	201
Antimony, Total	ug/L	P114	ND(5.97)	ND(5.97)	13.6	ND(5.97)
Arsenic, Total	ug/L	P115	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)
Barium, Total (e) (s)	ug/L		14.7	89.3	108	83.4
Beryllium, Total	ug/L	P117	ND(0.0540)	ND(0.0540)	ND(0.0540)	ND(0.0540)
Boron, Total (s)	ug/L		ND(3.37)	55.5	166	56.7
Cadmium, Total	ug/L	P118	ND(0.446)	ND(0.446)	1.50	ND(0.446)
Calcium, Total (e) (s)	ug/L		2,520	18,200	71,200	18,200
Chromium, Total	ug/L	P119	ND(1.68)	6.50	16.3	ND(1.68)
Cobalt, Total	ug/L		ND(0.914)	ND(0.914)	2.40	ND(0.914)
Copper, Total (e) (s)	ug/L	P120	258	975	400	88.3
Iron, Total (e) (s)	ug/L		229	5,730	3,010	2,530
Lead, Total (e)	ug/L	P122	8.90	50.2	45.3	10.7
Magnesium, Total (s)	ug/L		525	2,160	22,700	2,790
Manganese, Total (e) (s)	ug/L		6.50	75.0	434	36.3
Mercury, Total (s)	ug/L	P123	ND(0.0170)	0.330	ND(0.0170)	ND(0.0170)
Molybdenum, Total	ug/L		ND(1.50)	ND(1.50)	ND(1.50)	ND(1.50)

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with one grab sample for laundry, accommodations, and galley, and two grab samples for food pulper for the 24-hour sampling period. Results for the food pulper grab samples are reported as the average, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).

Table 4-1 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Nickel, Total (s)	ug/L	P124	10.7	29.4	41.6	25.8
Selenium, Total	ug/L	P125	0.960	0.820	16.5	0.770
Silver, Total	ug/L	P126	ND(1.28)	ND(1.28)	2.10	ND(1.28)
Sodium, Total (e) (s)	ug/L		63,700	30,100	376,000	31,800
Thallium, Total (s)	ug/L	P127	ND(0.00900)	ND(0.00900)	0.0100	ND(0.00900)
Tin, Total	ug/L		ND(3.45)	4.50	88.6	4.00
Titanium, Total (e)	ug/L		1.20	6.00	8.80	2.20
Vanadium, Total	ug/L		ND(0.679)	6.20	1.80	ND(0.679)
Yttrium, Total	ug/L		ND(0.222)	ND(0.222)	ND(0.222)	ND(0.222)
Zinc, Total (e) (s)	ug/L	P128	303	1,500	4,210	1,010
Aluminum, Dissolved (e) (s)	ug/L		63.3	268	614	114
Arsenic, Dissolved	ug/L	P115	ND(2.32)	ND(2.32)	5.70	ND(2.32)
Barium, Dissolved (e) (s)	ug/L		3.00	51.4	69.6	57.3
Boron, Dissolved (s)	ug/L		ND(3.37)	61.4	147	56.3
Calcium, Dissolved (e) (s)	ug/L		1,970	16,300	67,100	15,800
Chromium, Dissolved	ug/L	P119	ND(1.68)	ND(1.68)	2.40	ND(1.68)
Cobalt, Dissolved (s)	ug/L		1.50	ND(0.914)	7.60	1.20
Copper, Dissolved (e) (s)	ug/L	P120	182	90.3	17.5	50.9
Iron, Dissolved (e)	ug/L		72.8	3,270	527	1,510
Lead, Dissolved (e)	ug/L	P122	5.90	3.70	4.90	4.00
Magnesium, Dissolved (e) (s)	ug/L		437	1,960	20,900	2,510
Manganese, Dissolved (e) (s)	ug/L		5.80	41.6	8.10	26.5

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with one grab sample for laundry, accommodations, and galley, and two grab samples for food pulper for the 24-hour sampling period. Results for the food pulper grab samples are reported as the average, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).

Table 4-1 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-1) (a)	Accommodations (SP-3) (a)	Food Pulper (SP-4) (a)	Galley (SP-5) (a)
Mercury, Dissolved (s)	ug/L	P123	0.180	0.390	0.260	0.270
Nickel, Dissolved (s)	ug/L	P124	7.30	19.6	38.1	22.2
Selenium, Dissolved	ug/L	P125	ND(0.572)	0.670	6.80	0.840
Sodium, Dissolved (e) (s)	ug/L		59,900	29,300	388,000	29,800
Thallium, Dissolved	ug/L	P127	0.0200	ND(0.00900)	0.0800	0.0100
Tin, Dissolved	ug/L		ND(3.45)	ND(3.45)	29.9	6.40
Titanium, Dissolved (e)	ug/L		1.70	0.330	ND(0.253)	0.340
Vanadium, Dissolved	ug/L		1.20	ND(0.679)	0.940	ND(0.679)
Zinc, Dissolved (e) (s)	ug/L	P128	178	635	3,780	599
Volatile and Semivolatile Organics						
Bis(2-ethylhexyl)phthalate	ug/L	P066	29.1	32.6	261	33.2
Phenanthrene	ug/L	P081	ND(10.0)	ND(10.0)	ND(27.9)	ND(10.0)
Phenol	ug/L	P065	ND(10.0)	12.4	32.4	22.2
Tetrachloroethene	ug/L	P085	ND(10.0)	52.3	ND(0.277)	ND(10.0)
Trichloroethene	ug/L	P087	ND(10.0)	20.9	ND(0.277)	ND(10.0)

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with one grab sample for laundry, accommodations, and galley, and two grab samples for food pulper for the 24-hour sampling period. Results for the food pulper grab samples are reported as the average, followed by an indication of the number of results included in the average (e.g., [N=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).

Table 4-2

Influent to Treatment System Analytical Results, Holland America Veendam

Analytical results for the influent to treatment system for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Influent to treatment system samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-2 identifies sampling point location. Average influent to treatment concentrations determined from the daily results. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-6) (a) Day 1	Influent to Treatment (SP-6) (a) Day 2	Influent to Treatment (SP-6) (a) Day 3	Influent to Treatment (SP-6) (a) Day 4	Influent to Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		>1,370,000 [N=4]	>8,650,000 [N=3]	8,010,000 [N=2]	6,290,000 [N=3]	5,870,000 [N=3]	>6,040,000
Enterococci (b)	MPN/100 mL		>750,000 [N=4]	>1,110,000 [N=3]	4,950,000 [N=2]	1,340,000 [N=3]	2,910,000 [N=3]	>2,210,000
Fecal Coliform (b)	CFU/100 mL		8,390,000 [N=4]	10,900,000 [N=3]	71,000,000 [N=2]	68,300,000 [N=3]	6,970,000 [N=3]	33,100,000
Classical Pollutants								
Alkalinity (s)	mg/L		311	435	323	376	368	363
Ammonia as Nitrogen (NH3-N) (s)	mg/L		60.0	84.0	63.0	80.0	68.0	71.0
Biochemical Oxygen Demand (BOD_5)	mg/L		504	786	576	481	537	577
Chemical Oxygen Demand (COD)	mg/L		799	1,960	1,300	2,040	1,280	1,480
Chloride (s)	mg/L		72.0	88.0	75.0	84.0	76.0	79.0
Hardness (e) (s)	mg/L		47.6	78.3	68.5	74.6	71.0	68.0
Hexane Extractable Material (HEM) (c)	mg/L		41.0	79.0	129	164	88.0	100
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0600	0.0700	ND(0.0500)	ND(0.0500)	ND(0.0500)	<0.0560

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3 and 4. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-6) (a) Day 1	Influent to Treatment (SP-6) (a) Day 2	Influent to Treatment (SP-6) (a) Day 3	Influent to Treatment (SP-6) (a) Day 4	Influent to Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Settleable Residue	ML/L		40.0	82.0	22.0	66.0	69.0	55.8
Silica Gel Treated HEM (SGT-HEM) (c)	mg/L		6.10	7.00	34.5	14.5	10.0	14.4
Sulfate (s)	mg/L		26.0	33.0	30.0	32.0	28.0	29.8
Total Dissolved Solids (TDS) (s)	mg/L		453	492	510	435	432	464
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		91.0	141	103	86.0	103	105
Total Organic Carbon (TOC)	mg/L		182	187	192	235	195	198
Total Phosphorus	mg/L		10.0	13.0	13.0	19.0	20.0	15.0
Total Suspended Solids (TSS)	mg/L		473	805	630	655	710	655
Total and Dissolved Metals								
Aluminum, Total	ug/L		419	597	508	597	532	531
Antimony, Total	ug/L	P114	ND(5.97)	ND(5.97)	ND(5.97)	ND(5.97)	ND(5.97)	ND(5.97)
Arsenic, Total	ug/L	P115	ND(2.32)	2.60	ND(2.32)	ND(2.32)	2.50	<2.41
Barium, Total (e) (s)	ug/L		59.1	71.0	64.6	65.2	60.6	64.1
Beryllium, Total	ug/L	P117	ND(0.0540)	ND(0.0540)	ND(0.0540)	ND(0.0540)	ND(0.0540)	ND(0.0540)
Boron, Total (s)	ug/L		62.1	69.3	77.9	72.1	59.0	68.1
Cadmium, Total	ug/L	P118	ND(0.446)	0.460	ND(0.446)	ND(0.446)	ND(0.446)	< 0.449
Calcium, Total (e) (s)	ug/L		13,300	23,200	20,900	22,600	20,800	20,200
Chromium, Total	ug/L	P119	ND(1.68)	3.70	2.00	3.70	4.00	<3.02
Cobalt, Total	ug/L		ND(0.914)	ND(0.914)	ND(0.914)	ND(0.914)	ND(0.914)	ND(0.914)
Copper, Total (e) (s)	ug/L	P120	185	314	285	263	184	246

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3 and 4. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-6) (a) Day 1	Influent to Treatment (SP-6) (a) Day 2	Influent to Treatment (SP-6) (a) Day 3	Influent to Treatment (SP-6) (a) Day 4	Influent to Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Iron, Total (e) (s)	ug/L		1,590	1,590	1,740	1,700	1,430	1,610
Lead, Total (e)	ug/L	P122	14.8	9.20	4.90	3.90	ND(3.08)	<7.18
Magnesium, Total (s)	ug/L		3,500	4,940	3,970	4,420	4,630	4,290
Manganese, Total (e) (s)	ug/L		48.3	67.7	56.5	61.8	61.1	59.1
Mercury, Total (s)	ug/L	P123	0.360	0.500	0.520	ND(0.0170)	0.720	<0.423
Molybdenum, Total	ug/L		ND(1.50)	ND(1.50)	ND(1.50)	ND(1.50)	ND(1.50)	ND(1.50)
Nickel, Total (s)	ug/L	P124	35.7	33.0	24.2	21.6	21.9	27.3
Selenium, Total	ug/L	P125	1.10	1.50	1.00	1.30	1.40	1.26
Silver, Total	ug/L	P126	ND(1.28)	1.70	ND(1.28)	1.30	3.90	<1.89
Sodium, Total (e) (s)	ug/L		76,000	91,900	80,200	74,400	68,200	78,100
Thallium, Total (s)	ug/L	P127	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.000900)
Tin, Total	ug/L		ND(3.45)	ND(3.45)	ND(3.45)	6.80	4.40	<4.31
Titanium, Total (e)	ug/L		1.90	2.80	2.10	2.40	3.40	2.52
Vanadium, Total	ug/L		ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)
Yttrium, Total	ug/L		ND(0.222)	ND(0.222)	ND(0.222)	ND(0.222)	ND(0.222)	ND(0.222)
Zinc, Total (e) (s)	ug/L	P128	1,300	1,080	841	797	719	947
Aluminum, Dissolved (e) (s)	ug/L		107	31.0	51.4	238	65.3	98.5
Arsenic, Dissolved	ug/L	P115	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)
Barium, Dissolved (e) (s)	ug/L		19.8	14.5	18.1	34.1	15.7	20.4
Boron, Dissolved (s)	ug/L		63.2	68.8	71.2	72.8	62.3	67.7

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3 and 4. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-6) (a) Day 1	Influent to Treatment (SP-6) (a) Day 2	Influent to Treatment (SP-6) (a) Day 3	Influent to Treatment (SP-6) (a) Day 4	Influent to Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Calcium, Dissolved (e) (s)	ug/L		9,600	12,700	13,900	17,500	13,200	13,400
Chromium, Dissolved	ug/L	P119	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)
Cobalt, Dissolved (s)	ug/L		4.00	4.10	3.00	2.10	4.20	3.48
Copper, Dissolved (e) (s)	ug/L	P120	44.5	37.1	42.8	136	34.4	59.0
Iron, Dissolved (e)	ug/L		624	395	512	921	419	574
Lead, Dissolved (e)	ug/L	P122	3.10	ND(3.08)	ND(3.08)	ND(3.08)	ND(3.08)	<3.08
Magnesium, Dissolved (e) (s)	ug/L		2,780	3,680	3,020	3,900	3,480	3,370
Manganese, Dissolved (e) (s)	ug/L		18.1	20.8	17.2	37.6	20.7	22.9
Mercury, Dissolved (s)	ug/L	P123	0.350	0.320	0.330	0.420	0.380	0.360
Nickel, Dissolved (s)	ug/L	P124	33.3	26.3	20.7	17.2	16.0	22.7
Selenium, Dissolved	ug/L	P125	0.870	1.20	0.840	1.00	1.00	0.982
Sodium, Dissolved (e) (s)	ug/L		73,900	86,000	72,900	75,200	65,400	74,700
Thallium, Dissolved	ug/L	P127	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)
Tin, Dissolved	ug/L		ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)
Titanium, Dissolved (e)	ug/L		ND(0.253)	ND(0.253)	ND(0.253)	0.560	ND(0.253)	<0.314
Vanadium, Dissolved	ug/L		ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)
Zinc, Dissolved (e) (s)	ug/L	P128	634	288	199	357	111	318
Volatile and Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	10.1	15.3	20.3	24.0	ND(10.0)	<15.9
Phenanthrene	ug/L	P081	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3 and 4. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-6) (a) Day 1	Influent to Treatment (SP-6) (a) Day 2	Influent to Treatment (SP-6) (a) Day 3	Influent to Treatment (SP-6) (a) Day 4	Influent to Treatment (SP-6) (a) Day 5	Average Influent to Treatment (SP-6) (a)
Phenol	ug/L	P065	13.9	15.0	13.4	ND(10.0)	25.1	<15.5
Tetrachloroethene	ug/L	P085	443	274	147	1,360	2,740	993
Trichloroethene	ug/L	P087	32.2	20.1	24.4	66.9	58.0	40.3
Polychlorinated Biphenyls								
PCB-6	pg/L		60.0	NC	NC	NC	NC	
PCB-11	pg/L		496	NC	NC	NC	NC	
PCB-16	pg/L		124	NC	NC	NC	NC	
PCB-21+PCB-33	pg/L		230	NC	NC	NC	NC	
PCB-153+PCB-168	pg/L		610	NC	NC	NC	NC	
Total Dichloro Biphenyls	pg/L		556	NC	NC	NC	NC	
Total Hexachloro Biphenyls	pg/L		610	NC	NC	NC	NC	
Total Trichloro Biphenyls	pg/L		354	NC	NC	NC	NC	
Total PCBs	pg/L		1520	NC	NC	NC	NC	

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3 and 4. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-3

Influent to UV Disinfection Analytical Results, Holland America Veendam

Analytical results for the influent to UV disinfection part of the wastewater treatment system. Influent to UV disinfection samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-2 identifies sampling point location. Average influent to UV concentrations determined from the daily results.

Analyte	Unit	Influent to UV (SP-8) (a) Day 1	Influent to UV (SP-8) (a) Day 2	Influent to UV (SP-8) (a) Day 3	Influent to UV (SP-8) (a) Day 4	Influent to UV (SP-8) (a) Day 5	Average Influent to UV (SP-8) (a)
Pathogen Indicators							
E. coli (b)	MPN/100 mL	97.9 [N=4]	7.33 [N=3]	< 1.50 [N=2]	< 1.02 [N=3]	43.2 [N=3]	<30.2
Enterococci (b)	MPN/100 mL	37.0 [N=4]	9.25 [N=2]	2.50 [N=2]	54.2 [N=3]	54.2 [N=3]	31.4
Fecal Coliform (b)	CFU/100 mL	100 [N=4]	12.0 [N=3]	6.00 [N=2]	< 3.80 [N=3]	< 13.1 [N=3]	<27.0

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples collected per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4

Effluent from Treatment System Analytical Results, Holland America Veendam

Analytical results for the effluent from treatment system for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Effluent from treatment system samples were collected for five consecutive 24-hour sampling periods; see Section 3.2 for the sample collection methodology. Figure 2-2 identifies sampling point location. Average effluent from treatment concentrations determined from the daily results. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-9) (a) Day 1	Effluent from Treatment (SP-9) (a) Day 2	Effluent from Treatment (SP-9) (a) Day 3	Effluent from Treatment (SP-9) (a) Day 4	Effluent from Treatment (SP-9) (a) Day 5	Average Effluent from Treatment (SP-9) (a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		ND(1.00)[N=4]	ND(1.00)[N=3]	ND(1.00)[N=2]	ND(1.00)[N=3]	ND(1.00)[N=3]	ND(1.00)
Enterococci (b)	MPN/100 mL		ND(1.00)[N=3]	ND(1.00)[N=3]	ND(1.00)[N=2]	< 1.68 [N=3]	ND(1.00)[N=3]	<1.14
Fecal Coliform (b)	CFU/100 mL		ND(1.00)[N=4]	ND(1.00)[N=3]	ND(1.00)[N=2]	ND(1.00)[N=3]	ND(1.00)[N=3]	ND(1.00)
Classical Pollutants								
Alkalinity (s)	mg/L		222	265	252	244	242	245
Ammonia as Nitrogen (NH3-N) (s)	mg/L		11.0	12.0	12.0	28.0	29.0	18.4
Biochemical Oxygen Demand (BOD_5)	mg/L		3.64	5.95	ND(2.00)	2.05	2.37	<3.20
Chemical Oxygen Demand (COD)	mg/L		33.5	37.0	34.0	38.0	42.5	37.0
Chloride (s)	mg/L		61.0	67.0	70.0	68.0	64.0	66.0
Hardness (e) (s)	mg/L		24.2	36.0	40.6	45.1	45.3	38.2
Hexane Extractable Material (HEM) (c)	mg/L		ND(5.00)	ND(6.00)	ND(5.00)	ND(5.50)	ND(6.00)	ND(5.50)
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		ND(0.0500)	0.120	0.110	ND(0.0500)	ND(0.0500)	<0.0760
Settleable Residue	mg/L		ND(0.100)	ND(0.130)	ND(0.110)	ND(0.110)	< 0.555	<0.201

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3, 4, and 5. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-9) (a) Day 1	Effluent from Treatment (SP-9) (a) Day 2	Effluent from Treatment (SP-9) (a) Day 3	Effluent from Treatment (SP-9) (a) Day 4	Effluent from Treatment (SP-9) (a) Day 5	Average Effluent from Treatment (SP-9) (a)
Silica Gel Treated HEM (SGT-HEM) (c)	mg/L		ND(5.00)	ND(6.00)	ND(5.00)	ND(5.50)	ND(6.00)	ND(5.50)
Sulfate (s)	mg/L		ND(3.00)	4.00	9.00	18.0	15.0	<9.80
Total Dissolved Solids (TDS) (s)	mg/L		324	386	354	318	309	338
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		34.0	13.0	22.0	29.0	28.5	25.3
Total Organic Carbon (TOC)	mg/L		12.5	16.0	14.0	15.0	13.0	14.1
Total Phosphorus	mg/L		0.190	0.120	0.130	9.00	7.50	3.39
Total Suspended Solids (TSS)	mg/L		ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Total and Dissolved Metals								
Aluminum, Total	ug/L		33.1	43.6	46.2	40.3	40.0	40.6
Antimony, Total	ug/L	P114	ND(5.97)	ND(5.97)	ND(5.97)	ND(5.97)	ND(5.97)	ND(5.97)
Arsenic, Total	ug/L	P115	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)
Barium, Total (e) (s)	ug/L		16.0	24.7	25.8	18.6	14.6	19.9
Beryllium, Total	ug/L	P117	ND(0.0540)	ND(0.0540)	ND(0.0540)	ND(0.0540)	ND(0.0540)	ND(0.0540)
Boron, Total (s)	ug/L		ND(3.37)	ND(3.37)	ND(3.37)	ND(3.37)	ND(3.37)	ND(3.37)
Cadmium, Total	ug/L	P118	ND(0.446)	ND(0.446)	ND(0.446)	ND(0.446)	ND(0.446)	ND(0.446)
Calcium, Total (e) (s)	ug/L		7,240	11,300	13,000	14,200	14,100	12,000
Chromium, Total	ug/L	P119	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)
Cobalt, Total	ug/L		ND(0.914)	ND(0.914)	ND(0.914)	ND(0.914)	ND(0.914)	ND(0.914)
Copper, Total (e) (s)	ug/L	P120	10.6	11.8	8.70	6.90	6.90	8.97

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3, 4, and 5. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-9) (a) Day 1	Effluent from Treatment (SP-9) (a) Day 2	Effluent from Treatment (SP-9) (a) Day 3	Effluent from Treatment (SP-9) (a) Day 4	Effluent from Treatment (SP-9) (a) Day 5	Average Effluent from Treatment (SP-9) (a)
Iron, Total (e) (s)	ug/L		376	296	367	283	171	298
Lead, Total (e)	ug/L	P122	ND(3.08)	ND(3.08)	ND(3.08)	ND(3.08)	ND(3.08)	ND(3.08)
Magnesium, Total (s)	ug/L		1,490	1,900	2,000	2,350	2,460	2,040
Manganese, Total (e) (s)	ug/L		12.2	16.2	18.1	18.4	15.8	16.1
Mercury, Total (s)	ug/L	P123	ND(0.0170)	ND(0.0170)	< 0.164	0.320	0.320	<0.168
Molybdenum, Total	ug/L		ND(1.50)	ND(1.50)	ND(1.50)	ND(1.50)	ND(1.50)	ND(1.50)
Nickel, Total (s)	ug/L	P124	23.8	18.3	14.6	11.8	8.00	15.3
Selenium, Total	ug/L	P125	< 0.586	0.840	0.680	0.830	0.970	<0.781
Silver, Total	ug/L	P126	ND(1.28)	ND(1.28)	ND(1.28)	ND(1.28)	ND(1.28)	ND(1.28)
Sodium, Total (e) (s)	ug/L		93,600	107,000	89,100	74,600	69,600	86,800
Thallium, Total (s)	ug/L	P127	ND(0.00900)	0.0100	ND(0.00900)	ND(0.00900)	ND(0.00900)	<0.00920
Tin, Total	ug/L		ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)
Titanium, Total (e)	ug/L		ND(0.253)	ND(0.253)	ND(0.253)	ND(0.253)	ND(0.253)	ND(0.253)
Vanadium, Total	ug/L		ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)	ND(0.679)
Yttrium, Total	ug/L		ND(0.222)	ND(0.222)	ND(0.222)	ND(0.222)	ND(0.222)	ND(0.222)
Zinc, Total (e) (s)	ug/L	P128	549	562	333	196	162	360
Aluminum, Dissolved (e) (s)	ug/L		34.7	41.9	37.2	38.6	34.6	37.4
Arsenic, Dissolved	ug/L	P115	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)	ND(2.32)
Barium, Dissolved (e) (s)	ug/L		15.6	24.5	25.8	18.2	14.5	19.7
Boron, Dissolved (s)	ug/L		ND(3.37)	ND(3.37)	ND(3.37)	ND(3.37)	20.7	<6.84

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3, 4, and 5. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-9) (a) Day 1	Effluent from Treatment (SP-9) (a) Day 2	Effluent from Treatment (SP-9) (a) Day 3	Effluent from Treatment (SP-9) (a) Day 4	Effluent from Treatment (SP-9) (a) Day 5	Average Effluent from Treatment (SP-9) (a)
Calcium, Dissolved (e) (s)	ug/L		7,090	11,200	13,000	14,000	14,000	11,800
Chromium, Dissolved	ug/L	P119	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)	ND(1.68)
Cobalt, Dissolved (s)	ug/L		< 0.957	ND(0.914)	ND(0.914)	ND(0.914)	1.50	<1.04
Copper, Dissolved (e) (s)	ug/L	P120	8.70	11.0	7.20	5.60	7.50	8.00
Iron, Dissolved (e)	ug/L		356	296	357	266	152	285
Lead, Dissolved (e)	ug/L	P122	ND(3.08)	ND(3.08)	ND(3.08)	ND(3.08)	ND(3.08)	ND(3.08)
Magnesium, Dissolved (e) (s)	ug/L		1,460	1,880	2,020	2,320	2,440	2,020
Manganese, Dissolved (e) (s)	ug/L		13.4	16.1	19.3	19.4	18.3	17.3
Mercury, Dissolved (s)	ug/L	P123	0.270	0.270	0.330	0.360	0.390	0.324
Nickel, Dissolved (s)	ug/L	P124	23.5	18.8	14.9	11.7	8.40	15.5
Selenium, Dissolved	ug/L	P125	< 0.606	0.720	0.805	0.700	0.900	<0.746
Sodium, Dissolved (e) (s)	ug/L		91,200	105,000	89,000	73,500	69,700	85,700
Thallium, Dissolved	ug/L	P127	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)	ND(0.00900)
Tin, Dissolved	ug/L		ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)	ND(3.45)
Titanium, Dissolved (e)	ug/L		< 0.317	ND(0.253)	< 0.297	ND(0.253)	ND(0.253)	<0.274
Vanadium, Dissolved	ug/L		ND(0.679)	0.760	ND(0.679)	ND(0.679)	ND(0.679)	<0.695
Zinc, Dissolved (e) (s)	ug/L	P128	534	553	323	191	164	353

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3, 4, and 5. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-9) (a) Day 1	Effluent from Treatment (SP-9) (a) Day 2	Effluent from Treatment (SP-9) (a) Day 3	Effluent from Treatment (SP-9) (a) Day 4	Effluent from Treatment (SP-9) (a) Day 5	Average Effluent from Treatment (SP-9) (a)
Volatile and Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)
Phenanthrene	ug/L	P081	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)
Phenol	ug/L	P065	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)
Tetrachloroethene	ug/L	P085	10.4	37.4	47.7	26.5	45.1	33.4
Trichloroethene	ug/L	P087	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with a minimum of two grab samples and a maximum of four grab samples per 24-hour sampling period. Results are reported as an average for each 24-hour sampling period, followed by an indication of the number of results included in the average (e.g., [N=3]). See Appendix A-1 for all individual grab sample results.
(c) Two sample volumes of HEM and SGT-HEM were inadvertently analyzed for Days 3, 4, and 5. Reported results for these analyses for these days are averaged results.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-5

Wastewater Treatment System: Performance Data for Pathogen Indicators, Holland America Veendam

Pathogen indicators performance data for the Veendam's Zenon wastewater treatment system. Average analyte concentrations were determined from the daily results presented in Tables 4-2 through 4-4. Percent removals were calculated using the average influent to and effluent from treatment analyte concentrations.

Analyte	Unit	Average Influent to Treatment Concentration (SP-6) (a)	Average Influent to UV Disinfection Concentration (SP-8) (a)	Average Effluent from Treatment Concentration (SP-10) (a)	Percent Removal
Pathogen Indicators					
E. coli	MPN/100 mL	> 6,040,000	<30.2	ND(1.00)	> 99
Enterococci	MPN/100 mL	> 2,210,000	31.4	<1.14	> 99
Fecal Coliform	CFU/100 mL	33,100,000	<27.0	ND(1.00)	> 99

(a) Sampling point location; see Figure 2-2.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - In an average, average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D). In a removal, indicates a minimum level of removal.

Table 4-6

Wastewater Treatment System: Performance Data for Analytes Other Than Pathogen Indicators, Holland America Veendam

Performance data for the Veendam's Zenon wastewater treatment system for analytes other than pathogen indicators detected in either the influent to or effluent from treatment. Range and average analyte concentrations were determined from the daily results presented in Tables 4-2 and 4-4. Percent removals were calculated using the average influent and effluent analyte concentrations. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Average Influent to Treatment Concentration (SP-6) (a)	Influent to Treatment Concentration Range (SP-6) (a)	Average Effluent from Treatment Concentration (SP-9) (a)	Effluent from Treatment Concentration Range (SP-9) (a)	Percent Removal
Classical Pollutants							
Alkalinity (s)	mg/L		363	311 - 435	245	222 - 265	32
Ammonia As Nitrogen (NH3-N) (s)	mg/L		71.0	60.0 - 84.0	18.4	11.0 - 29.0	74
Biochemical Oxygen Demand (BOD_5)	mg/L		577	481 - 786	<3.20	ND(2.00) - 5.95	> 99
Chemical Oxygen Demand (COD)	mg/L		1,480	799 - 2,040	37.0	33.5 - 42.5	97
Chloride (s)	mg/L		79.0	72.0 - 88.0	66.0	61.0 - 70.0	16
Hardness (e) (s)	mg/L		68.0	47.6 - 78.3	38.2	24.2 - 45.3	44
Hexane Extractable Material (HEM)	mg/L		100	41.0 - 164	ND(5.50)	ND(5.00) - ND(6.00)	> 95
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		<0.0560	ND(0.0500) - 0.0700	<0.0760	ND(0.0500) - 0.120	NC
Settleable Residue	mL/L		55.8	22.0 - 82.0	<0.201	ND(0.100) - <0.555	> 99
Silica Gel Treated HEM (SGT-HEM)	mg/L		14.4	6.10 - 34.5	ND(5.50)	ND(5.00) - ND(6.00)	> 62
Sulfate (s)	mg/L		29.8	26.0 - 33.0	<9.80	ND(3.00) - 18.0	67
Total Dissolved Solids (TDS) (s)	mg/L		464	432 - 510	338	309 - 386	27
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		105	86.0 - 141	25.3	13.0 - 34.0	76
Total Organic Carbon (TOC)	mg/L		198	182 - 235	14.1	12.5 - 16.0	93

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Treatment Concentration (SP-6) (a)	Influent to Treatment Concentration Range (SP-6) (a)	Average Effluent from Treatment Concentration (SP-9) (a)	Effluent from Treatment Concentration Range (SP-9) (a)	Percent Removal
Total Phosphorus	mg/L		15.0	10.0 - 20.0	3.39	0.120 - 9.00	77
Total Suspended Solids (TSS)	mg/L		655	473 - 805	ND(5.00)	ND(5.00)	> 99
Total and Dissolved Metals							
Aluminum, Total	ug/L		531	419 - 597	40.6	33.1 - 46.2	92
Arsenic, Total	ug/L	P115	<2.41	ND(2.32) - 2.60	ND(2.32)	ND(2.32)	> 3.8
Barium, Total (e) (s)	ug/L		64.1	59.1 - 71.0	19.9	14.6 - 25.8	69
Boron, Total (s)	ug/L		68.1	59.0 - 77.9	ND(3.37)	ND(3.37)	> 95
Cadmium, Total	ug/L	P118	<0.449	ND(0.446) - 0.460	ND(0.446)	ND(0.446)	> 0.62
Calcium, Total (e) (s)	ug/L		20,200	13,300 - 23,200	12,000	7,240 - 14,200	41
Chromium, Total	ug/L	P119	<3.02	ND(1.68) - 4.00	ND(1.68)	ND(1.68)	> 44
Copper, Total (e) (s)	ug/L	P120	246	184 - 314	8.97	6.90 - 11.8	96
Iron, Total (e) (s)	ug/L		1,610	1,430 - 1,740	298	171 - 376	81
Lead, Total (e)	ug/L	P122	<7.18	ND(3.08) - 14.8	ND(3.08)	ND(3.08)	> 57
Magnesium, Total (s)	ug/L		4,290	3,500 - 4,940	2,040	1,490 - 2,460	52
Manganese, Total (e) (s)	ug/L		59.1	48.3 - 67.7	16.1	12.2 - 18.4	73
Mercury, Total (s)	ug/L	P123	<0.423	ND(0.0170) - 0.720	<0.168	ND(0.0170) - 0.320	60
Nickel, Total (s)	ug/L	P124	27.3	21.6 - 35.7	15.3	8.00 - 23.8	44
Selenium, Total	ug/L	P125	1.26	1.00 - 1.50	<0.781	<0.586 - 0.970	38
Silver, Total	ug/L	P126	<1.89	ND(1.28) - 3.90	ND(1.28)	ND(1.28)	> 33
Sodium, Total (e) (s)	ug/L		78,100	68,200 - 91,900	86,800	69,600 - 107,000	NC
Thallium, Total (s)	ug/L	P127	ND(0.00900)	ND(0.00900)	<0.00920	ND(0.00900) - 0.0100	NC

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Treatment Concentration (SP-6) (a)	Influent to Treatment Concentration Range (SP-6) (a)	Average Effluent from Treatment Concentration (SP-9) (a)	Effluent from Treatment Concentration Range (SP-9) (a)	Percent Removal
Tin, Total	ug/L		<4.31	ND(3.45) - 6.80	ND(3.45)	ND(3.45)	> 20
Titanium, Total (e)	ug/L		2.52	1.90 - 3.40	ND(0.253)	ND(0.253)	> 90
Zinc, Total (e) (s)	ug/L	P128	947	719 - 1,300	360	162 - 562	62
Aluminum, Dissolved (e) (s)	ug/L		98.5	31.0 - 238	37.4	34.6 - 41.9	62
Barium, Dissolved (e) (s)	ug/L		20.4	14.5 - 34.1	19.7	14.5 - 25.8	3.6
Boron, Dissolved (s)	ug/L		67.7	62.3 - 72.8	<6.84	ND(3.37) - 20.7	90
Calcium, Dissolved (e) (s)	ug/L		13,400	9,600 - 17,500	11,800	7,090 - 14,000	11
Cobalt, Dissolved (s)	ug/L		3.48	2.10 - 4.20	<1.04	ND(0.914) - 1.50	70
Copper, Dissolved (e) (s)	ug/L	P120	59.0	34.4 - 136	8.00	5.60 - 11.0	86
Iron, Dissolved (e)	ug/L		574	395 - 921	285	152 - 357	50
Lead, Dissolved (e)	ug/L	P122	<3.08	ND(3.08) - 3.10	ND(3.08)	ND(3.08)	> 0.13
Magnesium, Dissolved (e) (s)	ug/L		3,370	2,780 - 3,900	2,020	1,460 - 2,440	40
Manganese, Dissolved (e) (s)	ug/L		22.9	17.2 - 37.6	17.3	13.4 - 19.4	24
Mercury, Dissolved (s)	ug/L	P123	0.360	0.320 - 0.420	0.324	0.270 - 0.390	10.0
Nickel, Dissolved (s)	ug/L	P124	22.7	16.0 - 33.3	15.5	8.40 - 23.5	32
Selenium, Dissolved	ug/L	P125	0.982	0.840 - 1.20	<0.746	<0.606 - 0.900	24
Sodium, Dissolved (e) (s)	ug/L		74,700	65,400 - 86,000	85,700	69,700 - 105,000	NC
Titanium, Dissolved (e)	ug/L		<0.314	ND(0.253) - 0.560	<0.274	ND(0.253) - <0.317	13
Vanadium, Dissolved	ug/L		ND(0.679)	ND(0.679)	<0.695	ND(0.679) - 0.760	NC
Zinc, Dissolved (e) (s)	ug/L	P128	318	111 - 634	353	164 - 553	NC

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Treatment Concentration (SP-6) (a)	Influent to Treatment Concentration Range (SP-6) (a)	Average Effluent from Treatment Concentration (SP-9) (a)	Effluent from Treatment Concentration Range (SP-9) (a)	Percent Removal
Volatile and Semivolatile Organics							
Bis(2-ethylhexyl)phthalate	ug/L	P066	<15.9	ND(10.0) - 24.0	ND(10.0)	ND(10.0)	> 37
Phenol	ug/L	P065	<15.5	ND(10.0) - 25.1	ND(10.0)	ND(10.0)	> 35
Tetrachloroethene	ug/L	P085	993	147 - 2,740	33.4	10.4 - 47.7	97
Trichloroethene	ug/L	P087	40.3	20.1 - 66.9	ND(10.0)	ND(10.0)	> 75

(a) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Percent removal not calculated because the effluent concentration was greater than the influent concentration, or the analyte was not detected in the influent sample.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-7

Treatment System Residuals and Incinerator Ash Analytical Results, Holland America Veendam

Analytical results for one-time grab samples of treatment system residuals (screening solids from two coarse screens and excess biological mass from bioreactors) and incinerator ash for analytes detected at least once in these samples. See Appendix A-2 for all analytical results (detected and nondetected). Figures 2-1 and 2-2 identify the sampling point locations; see Table 3-2 for sample collection methodology. Also shown are average concentrations for the influent to treatment samples (from Table 4-2) for comparison. Certain screening solids and waste biosludge results were converted from mass to volume units; see Section 3.3. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Priority Pollutant Code	Screening Solids (SP-11) (a)	Biosludge (SP-12) (a)	Incinerator Ash (SP-13) (a)	Average Influent to Treatment (SP-6) (a)
Classical Pollutants					
Alkalinity (s)		223 mg/L	499 mg/L	NC	363 mg/L
Ammonia as Nitrogen (NH3-N) (s)		21.6 mg/L	76.3 mg/L	NC	71.0 mg/L
Biochemical Oxygen Demand (BOD_5)		6,610 mg/L	3,870 mg/L	NC	577 mg/L
Chemical Oxygen Demand (COD)		12,300 mg/L	14,800 mg/L	NC	1,480 mg/L
Chloride (s)		137 mg/L	62.4 mg/L	NC	79.0 mg/L
Hardness (e) (s)		55.3 mg/L	49.2 mg/L	NC	68.0 mg/L
Settleable Residue		1,000 mL/L	560 mL/L	NC	55.8 mL/L
Sulfate (s)		90.2 mg/L	398 mg/L	NC	29.8 mg/L
Total Kjeldahl Nitrogen (TKN) (s)		470 mg/L	1,280 mg/L	NC	105 mg/L
Total Organic Carbon (TOC)		348 mg/L	75.5 mg/L	NC	198 mg/L
Total Phosphorus		75.9 mg/L	153 mg/L	NC	15.0 mg/L
Total Metals					
Aluminum, Total		19,200 ug/L	10,500 ug/L	44,800 mg/kg	531 ug/L
Antimony, Total	P114	25.8 ug/L	16.9 ug/L	28.3 mg/kg	ND(5.97) ug/L
Arsenic, Total	P115	ND(2.32) ug/L	7.60 ug/L	5.20 mg/kg	<2.41 ug/L

(a) Sampling point location; see Figures 2-1 and 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is the detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-7 (Continued)

Analyte	Priority Pollutant Code	Screening Solids (SP-11) (a)	Biosludge (SP-12) (a)	Incinerator Ash (SP-13) (a)	Average Influent to Treatment (SP-6) (a)
Barium, Total (e) (s)		1,950 ug/L	1,560 ug/L	837 mg/kg	64.1 ug/L
Beryllium, Total	P117	ND(0.0540) ug/L	ND(0.0540) ug/L	0.410 mg/kg	ND(0.0540) ug/L
Boron, Total (s)		286 ug/L	775 ug/L	585 mg/kg	68.1 ug/L
Cadmium, Total	P118	3.50 ug/L	5.20 ug/L	1.40 mg/kg	<0.449 ug/L
Calcium, Total (e) (s)		166,000 ug/L	132,000 ug/L	174,000 mg/kg	20,200 ug/L
Chromium, Total	P119	72.4 ug/L	64.1 ug/L	286 mg/kg	<3.02 ug/L
Cobalt, Total		9.30 ug/L	7.90 ug/L	13.7 mg/kg	ND(0.914) ug/L
Copper, Total (e) (s)	P120	2,180 ug/L	4,230 ug/L	6,510 mg/kg	246 ug/L
Iron, Total (e) (s)		59,600 ug/L	43,800 ug/L	28,500 mg/kg	1,610 ug/L
Lead, Total (e)	P122	40.6 ug/L	59.8 ug/L	417 mg/kg	<7.18 ug/L
Magnesium, Total (s)		33,600 ug/L	39,400 ug/L	13,600 mg/kg	4,290 ug/L
Manganese, Total (e) (s)		1,150 ug/L	980 ug/L	673 mg/kg	59.1 ug/L
Molybdenum, Total		26.5 ug/L	36.5 ug/L	42.8 mg/kg	ND(1.50) ug/L
Nickel, Total (s)	P124	160 ug/L	234 ug/L	223 mg/kg	27.3 ug/L
Selenium, Total	P125	16.7 ug/L	25.7 ug/L	1.39 mg/kg	1.26 ug/L
Silver, Total	P126	17.5 ug/L	30.1 ug/L	15.4 mg/kg	<1.89 ug/L
Sodium, Total (e) (s)		157,000 ug/L	142,000 ug/L	49,600 mg/kg	78,100 ug/L
Thallium, Total (s)	P127	0.0800 ug/L	ND(0.0450) ug/L	ND(1.53) mg/kg	ND(0.00900) ug/L
Tin, Total		76.9 ug/L	51.6 ug/L	61.6 mg/kg	<4.31 ug/L
Titanium, Total (e)		23.6 ug/L	7.10 ug/L	1,060 mg/kg	2.52 ug/L
Vanadium, Total		77.6 ug/L	21.8 ug/L	484 mg/kg	ND(0.679) ug/L
Yttrium, Total		ND(0.222) ug/L	ND(0.222) ug/L	3.10 mg/kg	ND(0.222) ug/L

(a) Sampling point location; see Figures 2-1 and 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is the detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-7 (Continued)

Analyte	Priority Pollutant Code	Screening Solids (SP-11) (a)	Biosludge (SP-12) (a)	Incinerator Ash (SP-13) (a)	Average Influent to Treatment (SP-6) (a)
Zinc, Total (e) (s)	P128	6,390 ug/L	5,930 ug/L	2,700 mg/kg	947 ug/L
Volatile and Semivolatile Organics					
Bis(2-ethylhexyl)phthalate	P066	91.6 ug/L	21.1 ug/L	2,260 ug/kg	<15.9 ug/L
Phenanthrene	P081	ND(28.8) ug/L	ND(13.5) ug/L	441 ug/kg	ND(10.0) ug/L
Phenol	P065	700 ug/L	875 ug/L	1,140 ug/kg	<15.5 ug/L
Tetrachloroethene	P085	1.66 ug/L	2.63 ug/L	NC	993 ug/L
Trichloroethene	P087	ND(0.283) ug/L	1.14 ug/L	NC	40.3 ug/L
Dioxins and Furans					
1,2,3,4,6,7,8-HpCDD		NC	NC	192 pg/g	NC
1,2,3,4,6,7,8-HpCDF		NC	NC	1,890 pg/g	NC
1,2,3,4,7,8,9-HpCDF		NC	NC	117 pg/g	NC
1,2,3,4,7,8-HxCDD		NC	NC	<11.8 pg/g	NC
1,2,3,4,7,8-HxCDF		NC	NC	188 pg/g	NC
1,2,3,6,7,8-HxCDD		NC	NC	17.5 pg/g	NC
1,2,3,6,7,8-HxCDF		NC	NC	187 pg/g	NC
1,2,3,7,8,9-HxCDD		NC	NC	29.2 pg/g	NC
1,2,3,7,8,9-HxCDF		NC	NC	<11.2 pg/g	NC
1,2,3,7,8-PeCDD		NC	NC	<8.2 pg/g	NC
1,2,3,7,8-PeCDF		NC	NC	42.4 pg/g	NC
2,3,4,6,7,8-HxCDF		NC	NC	426 pg/g	NC
2,3,4,7,8-PeCDF		NC	NC	130 pg/g	NC
2,3,7,8-TCDD		NC	NC	1.50 pg/g	NC

(a) Sampling point location; see Figures 2-1 and 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is the detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-7 (Continued)

Analyte	Priority Pollutant Code	Screening Solids (SP-11) (a)	Biosludge (SP-12) (a)	Incinerator Ash (SP-13) (a)	Average Influent to Treatment (SP-6) (a)
2,3,7,8-TCDF		NC	NC	35.2 pg/g	NC
Octachlorodibenzo-p-dioxin		NC	NC	427 pg/g	NC
Octachlorodibenzofuran		NC	NC	742 pg/g	NC

(a) Sampling point location; see Figures 2-1 and 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not collected.
ND - Not detected (number in parentheses is the detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 4-8

Source Water Analytical Results, Holland America Veendam

Analytical results for one-time grab sample of source water for detected analytes. See Appendix A-2 for all analytical results (detected and nondetected). Also shown are Federal drinking water standards for comparison. Priority pollutants (designated by EPA in 30 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Source Water (SP-15) (a)	Federal Drinking Water Standards (b)
Classical Pollutants				
Alkalinity	mg/L		57.0	
Ammonia As Nitrogen (NH3-N)	mg/L		0.0570	
Chloride	mg/L		15.0	250
Hardness	mg/L		68.5	
Nitrate/Nitrite (NO2-N + NO3-N)	mg/L		0.270	10 (Nitrate) 1 (Nitrite)
Sulfate	mg/L		21.0	250
Total Dissolved Solids (TDS)	mg/L		121	500
Total Kjeldahl Nitrogen (TKN)	mg/L		1.00	
Total and Dissolved Metals				
Barium, Total	ug/L		32.0	2,000
Boron, Total	ug/L		33.0	
Calcium, Total	ug/L		24,200	
Copper, Total	ug/L	P120	72.2	1,300
Iron, Total	ug/L		30.6	300
Magnesium, Total	ug/L		1,950	
Manganese, Total	ug/L		0.720	50
Mercury, Total	ug/L	P123	0.310	2.0
Nickel, Total	ug/L	P124	15.8	
Sodium, Total	ug/L		10,500	
Thallium, Total	ug/L	P127	0.0200	2.0
Zinc, Total	ug/L	P128	13.6	5,000
Aluminum, Dissolved	ug/L		14.8	
Barium, Dissolved	ug/L		30.9	
Boron, Dissolved	ug/L		39.1	
Calcium, Dissolved	ug/L		24,300	
Cobalt, Dissolved	ug/L		1.70	
Copper, Dissolved	ug/L	P120	59.7	
Magnesium, Dissolved	ug/L		1,960	
Manganese, Dissolved	ug/L		2.60	
Mercury, Dissolved	ug/L	P123	0.420	
Nickel, Dissolved	ug/L	P124	14.5	
Sodium, Dissolved	ug/L		10,500	
Zinc, Dissolved	ug/L	P128	8.40	

(a) Sampling point number; see Table 2-1.
(b) 40 CFR 141.62 National Primary Maximum Contaminant Levels for Inorganic Contaminants (nitrate/nitrite, barium, mercury, thallium); 40 CFR 141.51 National Primary Maximum Contaminant Level Goals for Inorganic Contaminants (copper); and 40 CFR 143.3 Secondary Maximum Contaminant Levels (chloride, sulfate, TDS, iron, manganese, zinc).

Table 4-9

Laundry Cleaning Agents Used Onboard, Holland America Veendam

Chemical Name	Ingredients According to Material Safety Data Sheets
Diver Alik-Liquid alkali	10% to 30% NaOH 3% to 7% sodium nitrolotriacetate
Renew Extra-Liquid Laundry Detergent	10% to 30% linear alcohol ethoxylate 3% to 7% sodium dodecylbenzene sulfonate 3% to 7% ethylene glycol monobutyl ether
Super Impede-Stain Remover	Unknown (MSDS not provided)
Divercide 6F-Liquid Laundry Sour (silicofluorides mineral acid)	10% to 30% hydrofluorosilic acid
Valid II-Fabric Softener (cationic surfactant)	10% to 30% ditallow diamido methosulphate 1% to 5% isopropanol
Emphasize-Starch and Sizing Blend	Sodium chloride Water Polyvinylacetate emulsion Modified corn starch

Table 4-10

Flow Data by Sampling Period, Holland America Veendam

Flow data collected via strap-on ultrasonic flow meter for the laundry and via the Veendam's in-line flow meters for the influent to and effluent from the treatment system (see Section 4.3). Total daily flow data for the influent to treatment system were calculated from flow readings recorded from the Veendam's in-line flow meters installed on the graywater and sewage lines that feed into the treatment system. These sources added together equal the total flow into the treatment system. Figures 2-1 and 2-2 show the flow meter locations. Flow per capita was calculated by dividing the daily flow totals by the total number of passengers and crew (1,820 people) onboard the Veendam during the sampling episode.

	Laundry (SP-1)		Influent to Treatment System (SP-6)						Effluent from Treatment System (SP-9)	
Sampling Period	Strap-on Daily Total Flow, gal/day (m^3/day) (a)	Daily Flow Per Capita, gal/day/person (m^3/day/person)	In-line Sewage Daily Total Flow, gal/day (m^3/day) (b)	Sewage Daily Flow Per Capita, gal/day/person (m^3/day/person)	In-line Graywater Daily Total Flow, gal/day (m^3/day) (b)	Graywater Daily Flow Per Capita, gal/day/person (m^3/day/person)	In-line Daily Total Flow, gallons/day (m^3/day) (c)	Combined Sewage and Graywater Daily Flow Per Capita, gal/day/person (m^3/day/person)	In-line Daily Total Flow, gal/day (m^3/day) (b)	Daily Flow Per Capita, gal/day/person (m^3/day/person)
Day 1	26,700 (101)	14.7 (0.055)	31,100 (118)	17.1 (0.065)	82,300 (312)	45.2 (0.171)	113,000 (429)	62.3 (0.236)	109,000 (412)	59.8 (0.226)
Day 2	23,200 (88.0)	12.8 (0.048)	33,000 (125)	18.1 (0.069)	81,300 (308)	44.7 (0.169)	114,000 (432)	62.8 (0.238)	103,000 (388)	56.3 (0.213)
Day 3	26,700 (101)	14.7 (0.055)	31,700 (120)	17.4 (0.066)	81,800 (310)	45 (0.17)	114,000 (430)	62.4 (0.236)	50,000 (189) (d)	27.5 (0.104) (d)
Day 4	21,400 (81.0)	11.7 (0.045)	29,800 (113)	16.4 (0.062)	81,800 (310)	44.9 (0.17)	112,000 (422)	61.3 (0.232)	97,600 (370)	53.6 (0.203)
Day 5	20,600 (78.0)	11.3 (0.043)	31,200 (118)	17.2 (0.065)	79,000(299)	43.4 (0.164)	110,000 (417)	60.6 (0.229)	115,000 (435)	63.1 (0.239)
Average	23,800 (90.0)	13.1 (0.049)	31,400 (119)	17.2 (0.065)	81,200 (307)	44.6 (0.169)	113,000 (426)	61.9 (0.234)	106,000 (401) (d)	58.2 (0.220) (d)

(a) Flow data collected from strap-on flow meter installed by the sampling team.
(b) Flow data calculated from flow readings recorded from the Veendam's in-line flow meters; see Section 4.3.
(c) Influent to treatment flow was calculated by adding flow data collected from in-line flow meters installed on the graywater and sewage lines that feed into the treatment system.
(d) Average daily discharge flow rate for effluent from treatment system excludes data for Day 3 when the Veendam discontinued discharge while it cruised Glacier Bay National Park.

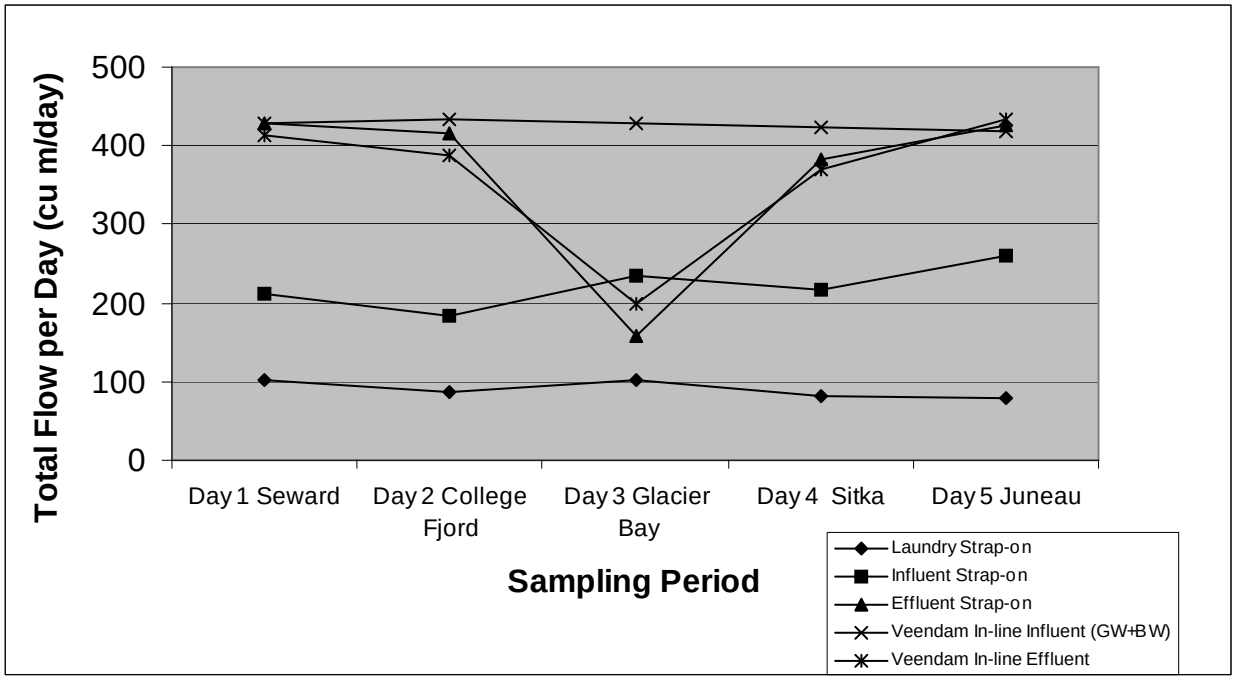

Figure 4-1. Total Daily Flow, Holland America Veendam

Flow data collected via strap-on ultrasonic flow meters installed by the sampling team and from the Veendam's in-line flow meters. Flow data are presented as daily totals calculated for each location. Combined, the in-line flow meters on the sewage and graywater tank discharges represent the flow into the treatment system. Figures 2-1 and 2-2 show the flow meter locations. Flow data recorded by the strap-on flow meter installed at the influent to treatment are suspect.

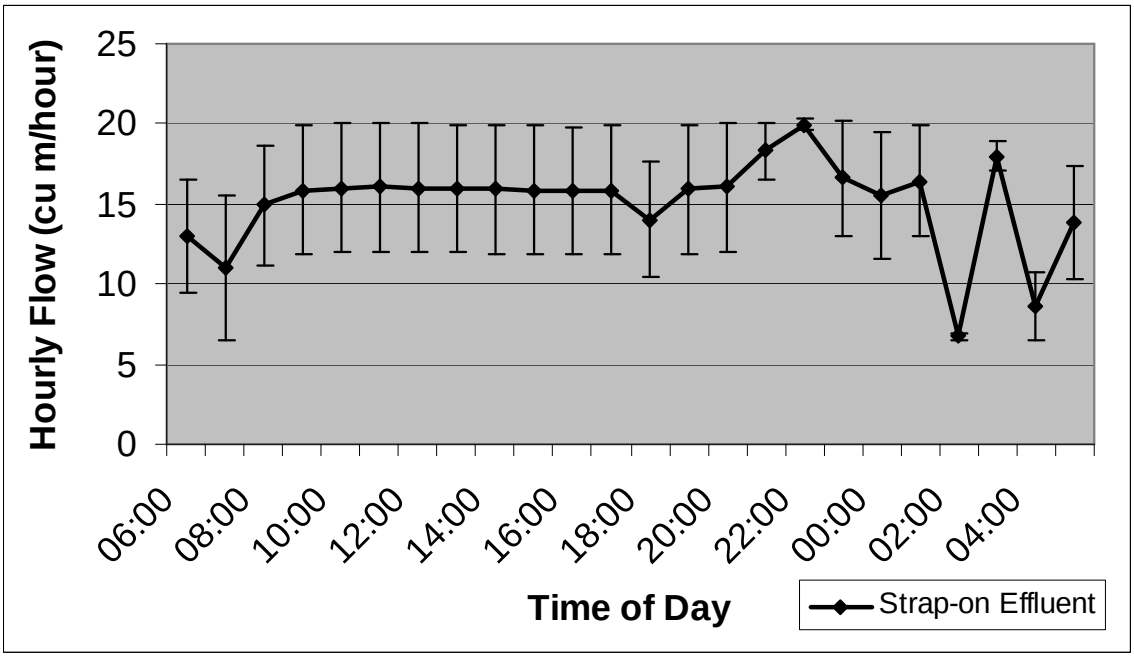

Figure 4-2. Average Hourly Wastewater Treatment System Flow, Holland America Veendam

Average effluent flow for each hour interval over the five consecutive 24-hour sampling periods, calculated and plotted from the strap-on flow meter installed by the sampling team. Figure 2-2 shows the flow meter location. Bars represent the standard deviation of the hourly flow calculated for the five consecutive sampling days.

5.0 DATA QUALITY

Quality assurance/quality control (QA/QC) procedures applicable to the Veendam sampling episode are outlined in the *Quality Assurance Project Plan for Rulemaking Support for Large Cruise Ships in Alaska Waters (QAPP)*, which is included in the Cruise Ship Rulemaking Record and is available upon request. This section describes the quality control practices used to assess the precision and accuracy of the analytical data presented in Section 4.0. Quality control (QC) practices used for this sampling episode include the analysis of matrix spikes, duplicate samples, and quality control standard checks.

5.1 Analytical Quality Control

EPA verified that laboratory performance was acceptable by conductig quality checks of the analytical data as specified by the QAPP. Data review chemists prepared written data review narratives (Appendix D) describing any qualifications of the analytical data. The following data were not considered to be of acceptable quality for the reasons discussed in Appendix D and were excluded from the data set:

- Three pesticides:
  - Norflurazon in samples 65215, 65227, and 65240,
  - Ancephate in sample 65227, and
  - Kepone in sample 65240.

- One pathogen indicator:
  - Enterococci in sample 65262.

- Four semivolatile organics:
  - Benzidine for all samples, and
  - 4-Nitrophenol, pentachlorophenol, and hexachlorocyclopentadiene in sample 65293.

5.1.1 Cyanide Results

There was uncertainty regarding the analytical results for available and total cyanide. Although these data have not been excluded from the database, the results are presented in Table 5-1 and not in the analytical results summary tables in Section 4.1. Available cyanide was detected in many samples, while total cyanide was not detected in these samples. In theory, the total cyanide results for any given sample will be greater than the available cyanide results in the same sample. Further investigation identified multiple issues with sample collection and analysis that may have led to the irreconcilable results for total and available cyanide in these samples, including poor matrix spike/matrix spike duplicate recoveries for total cyanide, lack of treatment to remove sulfides interferences for some samples, and poor agreement of duplicate sample results (see memoranda *Data Review Narrative for Classical Analyses for the Alaska Cruise Ship Industry Episode 6503* and *Issues Associated with Results for Total Cyanide Versus Available Cyanide* in Appendix D for a complete discussion). Because it was not possible to determine which analysis was correct, EPA flagged the irreconcilable results in the database to alert data users to the presence of such problems.

EPA did not identify any known source of cyanide onboard the Veendam during its onboard interviews regarding activities that impact wastewater generation.

5.1.2 Mercury Results

There was expressed uncertainty regarding the analytical results for total and dissolved mercury because these analytes were detected in a laboratory blank at concentrations greater than the method detection limit (MDL). See data review narrative for total and dissolved metals analyses in Appendix D for a complete discussion. Although other metals analytes were detected in laboratory blanks at concentrations greater than the MDL, total mercury was the only

analyte that was detected in the treatment effluent above one or more water quality criteria/standards.

5.2 Field Quality Control

The trip blank, equipment blank, and field duplicate results are the field QA/QC measures discussed in this subsection. Section 3.8 of the Veendam SAP discusses field QC specifications. Tables presented in this section of this document include results for only those analytes detected in the field QC samples during the sampling episode. Appendices A-1 and A-2 contain the results for all analytes, both detected and nondetected.

5.2.1 Trip Blank

A trip blank was collected and analyzed for volatile organics to evaluate possible contamination during shipment and handling of samples. This sample consisted of high performance liquid chromatography (HPLC) water. The trip blank was prepared prior to the start of the sampling episode, and accompanied samples shipped to the laboratory on June 25, 2004.

No volatile organics were detected in the trip blank, indicating that there was no contamination of samples during transport, field handling, storage, or shipping. (Note that there is no table with the results of the analyses in this section of the report because all results are nondetects.)

5.2.2 Equipment Blank

The sampling team collected an equipment blank to assess the potential introduction of contaminants by sample collection equipment. The sample collection equipment used to collect the equipment blank was the same as that used at the sampling points: approximately 4 feet of Teflon® tubing connected on one end to a series of metal plumbing fixtures installed on each sample port, and the other end to a small segment of silicone tubing

used in the peristaltic pump mechanism of the automatic sampler. The equipment blank was collected by pumping HPLC water through this equipment directly into sample bottles.

Table 5-2 presents the detected results for the equipment blank. Nine total metals and 11 dissolved metals were detected in the equipment blank. Table 5-2 also includes a value for hardness (a classical analyte), which was calculated based on the total magnesium and calcium concentrations detected in the sample using Standard Method 2340B. In tables presenting the analytical results in Section 4.1, all 20 of these metal analytes and hardness are flagged with an "(e)" to indicate they were detected in the equipment blank. EPA will consider the impact of possible contamination from sampling equipment in a future analysis.

5.2.3 Field Duplicates

Field duplicate samples were collected to assess the precision of the entire sample collection, handling, preparation, and analysis process. The relative percent difference (RPD) between the two duplicate sample results is calculated and compared to the data quality objective. For this program, the QAPP provides an RPD target for field duplicate samples as less than 30% for all analytes of a specific analytical method.

Classical Pollutants (Except HEM/SGT-HEM), Total and Dissolved Metals, and Semivolatile Organics

For classical pollutants (except HEM/SGT-HEM), total and dissolved metals, and semivolatile organics, field duplicate samples were samples collected from the same source, at the same time, then stored and analyzed independently. The duplicate samples were collected as split samples poured from the same mixed sample composite jars to minimize sample wastestream variability. Duplicate samples for these analytes were collected from the effluent from the wastewater treatment system (SP-9/10), except for the following: duplicate samples for dioxins and furans analytes were collected from the laundry graywater (SP-1/2), and duplicate samples for pesticides analytes were collected from the influent to the wastewater treatment system (SP-6/7).

Table 5-3 presents analytical results and the RPDs for these duplicate samples and includes analytical results for only those analytes that were detected at least once in wastewater samples (i.e., graywater sources, influent to treatment system, or effluent from treatment system) during the sampling episode. Duplicate sample results for pesticides and dioxins and furans are not shown in Table 5-3 because these analytes were not detected in any wastewater samples during the sampling episode, including these duplicate samples.

There was excellent precision in sampling and analysis for this sampling episode. Of the 134 duplicate pairs listed in Table 5-3, 122 either achieved the RPD target, or the RPD could not be calculated because both of the duplicate samples were less than the detection limit. The RPD could not be calculated for 9 of the duplicate pairs because the analyte was detected in one sample but not the other. Analytical variability increases as analyte concentrations approach their detection limits. The three duplicate pairs with an RPD outside of the target (i.e., $\geq$30% difference) include one of two duplicate pairs for each of aluminum, dissolved mercury, and total Kjeldahl nitrogen. These results are not uncommon in complex wastewater samples.

In tables presenting the analytical results in Section 4.1, duplicate sample results are presented as averages (calculation uses detection limits for nondetected results).

Pathogen Indicators, HEM/SGT-HEM, Volatile Organics, and Dioxins and Furans in Incinerator Ash

For pathogen indicators, HEM/SGT-HEM, volatile organics, and dioxins and furans in incinerator ash, field duplicate samples were collected sequentially and not as split samples as was done for the other analytes. For these samples, this methodology introduced sample wastestream variability into the assessment of the precision of sample collection and analysis. Duplicate samples for these analytes were collected from the effluent from the treatment system (SP-9/10), except for the following: one duplicate sample pair for pathogen indicators and two duplicate sample pairs for HEM/SGT-HEM were collected from the influent to the treatment system (SP-6/7), and one duplicate sample pair for pathogen indicators was collected from the influent to UV disinfection (SP-8). Duplicate samples for dioxins and furans were collected from the incinerator ash (SP-13/14). As discussed in Section 3.6, collection and

analysis of duplicate samples for analysis of HEM/SGT-HEM is a deviation from the Veendam SAP. In addition, collection and analysis of pathogen indicators duplicate samples at sampling locations other than the effluent from the treatment system (SP-9/10) was also a deviation from the Veendam SAP (see Section 3.6). Table 5-4 presents analytical results and the RPDs for these duplicate samples.

The RPD target of less than 30% may not be appropriate for these duplicate samples because the wastestreams are expected to be variable. As shown in Table 5-4, for influent to treatment and influent to UV disinfection wastewaters, 5 of the 10 duplicate sample pairs had RPDs greater than 30%. Of the 37 duplicate sample pairs listed in Table 5-4 for the effluent from treatment, one achieved the QAPP-specified RPD target, and for 33, the RPD could not be calculated because both of the duplicate samples was less than the detection limit. The RPD could not be calculated for one of the duplicate pairs because the analyte was detected in one sample but not the other. The two sample pairs with an RPD outside of the target (i.e., $\geq$30% difference) were for tetrachloroethene. For incinerator ash samples, 12 of the 17 duplicate sample pairs had RPDs greater than 30%.

In tables presenting the analytical results in Section 4.1, duplicate sample results are presented as averages (calculation uses detection limits for nondetected results). In the case of pathogen indicators, average daily results presented incorporate both duplicate grab samples and multiple grab samples collected for individual analysis during each 24-hour sampling period. First, duplicate results, where applicable, were averaged to determine the average individual grab sample results for that sample (e.g., grab 1 duplicate sample results for Day 3 were averaged together to represent the average grab 1 sample result for Day 3). Next, the individual grab sample results for each day were averaged to calculate the average daily pathogen indicators results presented in the tables (e.g., grab sample results 1 through 3 for Day 3 were averaged together to calculate the average Day 3 pathogen indicators sample results). In this way, the average daily pathogen indicators results presented in the tables are weighted equally by time of day, rather than weighted more heavily by the particular time of day when duplicate grab samples were collected.

Table 5-1

Available and Total Cyanide Analytical Results, Holland America Veendam

Available and total cyanide analytical results are irreconcilable; see Section 5.1.1.

Waste Stream	Available Cyanide (ug/L)	Total Cyanide (ug/L)
Laundry (SP-1)	ND(2.00)	ND(5.00)
Accommodations (SP-3)	15.7	ND(5.00)
Food Pulper (SP-4)	88.4	14.0
Galley (SP-5)	ND(2.00)	ND(5.00)
Influent to Treatment (SP-6), Day 1	10.4	ND(5.00)
Influent to Treatment (SP-6), Day 2	ND(2.00)	ND(5.00)
Influent to Treatment (SP-6), Day 3	7.54	ND(5.00)
Influent to Treatment (SP-6), Day 4	35.4	ND(5.00)
Influent to Treatment (SP-6), Day 5	16.0	ND(5.00)
Effluent from Treatment (SP-9), Day 1	< 5.48	ND(5.00)
Effluent from Treatment (SP-9), Day 2	< 3.93	ND(5.00)
Effluent from Treatment (SP-9), Day 3	ND(2.00)	ND(5.00)
Effluent from Treatment (SP-9), Day 4	ND(2.00)	ND(5.00)
Effluent from Treatment (SP-9), Day 5	2.01	ND(5.00)
Screening Solids (SP-11)	ND(2.00)	ND(5.00)
Biosludge (SP-12)	ND(2.00)	ND(5.00)
Source Water (SP-15)	19.1	ND(5.00)

< - Average result includes at least one nondetect value (calculation uses detection limits for nondetect results).
ND - Not detected (number in parentheses is detection limit).

Table 5-2

Equipment Blank Analytical Results, Holland America Veendam

Analytical results for analytes detected in the equipment blank. See Appendix A-2 for all analytical results (detected and nondetected). The equipment blank was collected as a one-time grab sample. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Equipment Blank (SP-17)
Classical Pollutants			
Hardness	mg/L		0.170
Total and Dissolved Metals			
Barium, Total	ug/L		8.00
Calcium, Total	ug/L		58.2
Copper, Total	ug/L	P120	23.5
Iron, Total	ug/L		191
Lead, Total	ug/L	P122	27.8
Manganese, Total	ug/L		5.20
Sodium, Total	ug/L		197
Titanium, Total	ug/L		0.440
Zinc, Total	ug/L	P128	256
Aluminum, Dissolved	ug/L		406
Barium, Dissolved	ug/L		21.2
Calcium, Dissolved	ug/L		53.2
Copper, Dissolved	ug/L	P120	3.10
Iron, Dissolved	ug/L		35.1
Lead, Dissolved	ug/L	P122	77.2
Magnesium, Dissolved	ug/L		12.4
Manganese, Dissolved	ug/L		5.80
Sodium, Dissolved	ug/L		260
Titanium, Dissolved	ug/L		0.960
Zinc, Dissolved	ug/L	P128	46.5

Table 5-3

Field Duplicate Analytical Results for Classical Pollutants (Except HEM/SGT-HEM), Total and Dissolved Metals, and Semivolatile Organics, Holland America Veendam

Field duplicate analytical results for classical pollutants (except HEM/SGT-HEM), total and dissolved metals, and semivolatile organics, detected at least once in wastewater samples during the sampling episode. See Appendix A-2 for all field duplicate analytical results (detected and nondetected). Field duplicate samples for these analytes are split samples collected from the same source, at the same time, stored and analyzed independently. Results for duplicate samples for pesticides from the influent to treatment (SP-6/7) and dioxins and furans from the laundry wastewater (SP-1/2) are not presented in this table as these analytes were not detected in these samples. See Figure 2-2 for the sampling point locations. Also listed are the average result and relative percent difference calculated for each duplicate pair. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Classical Pollutants								
Alkalinity (s)	mg/L		65261	65281	222	222	222	0.0
Alkalinity (s)	mg/L		65265	65283	261	269	265	3.0
Ammonia As Nitrogen (NH3-N) (s)	mg/L		65261	65281	11.0	11.0	11.0	0.0
Ammonia As Nitrogen (NH3-N) (s)	mg/L		65277	65289	29.0	29.0	29.0	0.0
Available Cyanide (s)	ug/L	P121	65261	65281	ND(2.00)	8.96	< 5.48	NC
Available Cyanide (s)	ug/L	P121	65265	65283	5.86	ND(2.00)	< 3.93	NC
Biochemical Oxygen Demand (BOD_5)	mg/L		65269	65285	ND(2.00)	ND(2.00)	ND(2.00)	NC
Biochemical Oxygen Demand (BOD_5)	mg/L		65277	65289	2.24	2.49	2.37	11
Chemical Oxygen Demand (COD)	mg/L		65261	65281	34.0	33.0	33.5	3.0
Chemical Oxygen Demand (COD)	mg/L		65277	65289	39.0	46.0	42.5	16

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Chloride (s)	mg/L		65261	65281	60.0	62.0	61.0	3.3
Chloride (s)	mg/L		65265	65283	68.0	66.0	67.0	3.0
Hardness (e) (s)	mg/L		65261	65281	24.4	24.0	24.2	1.7
Hardness (e) (s)	mg/L		65269	65285	40.4	40.7	40.6	0.74
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65261	65281	ND(0.050)	ND(0.050)	ND(0.050)	NC
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65277	65289	ND(0.050)	ND(0.050)	ND(0.050)	NC
Settleable Residue	mL/L		65273	65287	ND(0.110)	ND(0.110)	ND(0.110)	NC
Settleable Residue	mL/L		65277	65289	1.00	ND(0.11)	< 0.555	NC
Sulfate (s)	mg/L		65261	65281	ND(3.00)	ND(3.00)	ND(3.00)	NC
Sulfate (s)	mg/L		65265	65283	4.00	4.00	4.00	0.0
Total Cyanide	mg/L	P121	65261	65281	ND(0.005)	ND(0.005)	ND(0.005)	NC
Total Cyanide	mg/L	P121	65265	65283	ND(0.005)	ND(0.005)	ND(0.005)	NC
Total Dissolved Solids (TDS) (s)	mg/L		65261	65281	323	324	324	0.31
Total Dissolved Solids (TDS) (s)	mg/L		65265	65283	385	386	386	0.26
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65261	65281	12.0	56.0	34.0	130
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65277	65289	29.0	28.0	28.5	3.5
Total Organic Carbon (TOC)	mg/L		65261	65281	13.0	12.0	12.5	8.0
Total Organic Carbon (TOC)	mg/L		65277	65289	14.0	12.0	13.0	15

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Total Phosphorus	mg/L		65261	65281	0.210	0.170	0.190	21
Total Phosphorus	mg/L		65277	65289	7.00	8.00	7.50	13
Total Suspended Solids (TSS)	mg/L		65261	65281	ND(5.00)	ND(5.00)	ND(5.00)	NC
Total Suspended Solids (TSS)	mg/L		65265	65283	ND(5.00)	ND(5.00)	ND(5.00)	NC
Total and Dissolved Metals								
Aluminum, Total	ug/L		65261	65281	36.8	29.4	33.1	22
Aluminum, Total	ug/L		65269	65285	28.4	63.9	46.2	77
Aluminum, Dissolved (e) (s)	ug/L		65261	65281	33.1	36.2	34.7	8.9
Aluminum, Dissolved (e) (s)	ug/L		65269	65285	34.3	40.0	37.2	15
Antimony, Total	ug/L	P114	65261	65281	ND(5.97)	ND(5.97)	ND(5.97)	NC
Antimony, Total	ug/L	P114	65269	65285	ND(5.97)	ND(5.97)	ND(5.97)	NC
Arsenic, Total	ug/L	P115	65261	65281	ND(2.32)	ND(2.32)	ND(2.32)	NC
Arsenic, Total	ug/L	P115	65269	65285	ND(2.32)	ND(2.32)	ND(2.32)	NC
Arsenic, Dissolved	ug/L	P115	65261	65281	ND(2.32)	ND(2.32)	ND(2.32)	NC
Arsenic, Dissolved	ug/L	P115	65269	65285	ND(2.32)	ND(2.32)	ND(2.32)	NC
Barium, Total (e) (s)	ug/L		65261	65281	16.2	15.8	16.0	2.5
Barium, Total (e) (s)	ug/L		65269	65285	25.7	25.8	25.8	0.39
Barium, Dissolved (e) (s)	ug/L		65261	65281	15.4	15.7	15.6	1.9
Barium, Dissolved (e) (s)	ug/L		65269	65285	26.3	25.2	25.8	4.3

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Beryllium, Total	ug/L	P117	65261	65281	ND(0.054)	ND(0.054)	ND(0.054)	NC
Beryllium, Total	ug/L	P117	65269	65285	ND(0.054)	ND(0.054)	ND(0.054)	NC
Boron, Total (s)	ug/L		65261	65281	ND(3.37)	ND(3.37)	ND(3.37)	NC
Boron, Total (s)	ug/L		65269	65285	ND(3.37)	ND(3.37)	ND(3.37)	NC
Boron, Dissolved (s)	ug/L		65261	65281	ND(3.37)	ND(3.37)	ND(3.37)	NC
Boron, Dissolved (s)	ug/L		65269	65285	ND(3.37)	ND(3.37)	ND(3.37)	NC
Cadmium, Total	ug/L	P118	65261	65281	ND(0.446)	ND(0.446)	ND(0.446)	NC
Cadmium, Total	ug/L	P118	65269	65285	ND(0.446)	ND(0.446)	ND(0.446)	NC
Calcium, Total (e) (s)	ug/L		65261	65281	7,290	7,190	7,240	1.4
Calcium, Total (e) (s)	ug/L		65269	65285	12,900	13,000	13,000	0.77
Calcium, Dissolved (e) (s)	ug/L		65261	65281	7,100	7,070	7,090	0.42
Calcium, Dissolved (e) (s)	ug/L		65269	65285	13,200	12,700	13,000	3.9
Chromium, Total	ug/L	P119	65261	65281	ND(1.68)	ND(1.68)	ND(1.68)	NC
Chromium, Total	ug/L	P119	65269	65285	ND(1.68)	ND(1.68)	ND(1.68)	NC
Chromium, Dissolved	ug/L	P119	65261	65281	ND(1.68)	ND(1.68)	ND(1.68)	NC
Chromium, Dissolved	ug/L	P119	65269	65285	ND(1.68)	ND(1.68)	ND(1.68)	NC
Cobalt, Total	ug/L		65261	65281	ND(0.914)	ND(0.914)	ND(0.914)	NC
Cobalt, Total	ug/L		65269	65285	ND(0.914)	ND(0.914)	ND(0.914)	NC
Cobalt, Dissolved (s)	ug/L		65261	65281	1.00	ND(0.914)	< 0.957	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Cobalt, Dissolved (s)	ug/L		65269	65285	ND(0.914)	ND(0.914)	ND(0.914)	NC
Copper, Total (e) (s)	ug/L	P120	65261	65281	10.1	11.0	10.6	8.5
Copper, Total (e) (s)	ug/L	P120	65269	65285	9.00	8.40	8.70	6.9
Copper, Dissolved (e) (s)	ug/L	P120	65261	65281	8.70	8.70	8.70	0.0
Copper, Dissolved (e) (s)	ug/L	P120	65269	65285	7.20	7.20	7.20	0.0
Iron, Total (e) (s)	ug/L		65261	65281	376	375	376	0.27
Iron, Total (e) (s)	ug/L		65269	65285	364	369	367	1.4
Iron, Dissolved (e)	ug/L		65261	65281	354	358	356	1.1
Iron, Dissolved (e)	ug/L		65269	65285	363	351	357	3.4
Lead, Total (e)	ug/L	P122	65261	65281	ND(3.08)	ND(3.08)	ND(3.08)	NC
Lead, Total (e)	ug/L	P122	65269	65285	ND(3.08)	ND(3.08)	ND(3.08)	NC
Lead, Dissolved (e)	ug/L	P122	65261	65281	ND(3.08)	ND(3.08)	ND(3.08)	NC
Lead, Dissolved (e)	ug/L	P122	65269	65285	ND(3.08)	ND(3.08)	ND(3.08)	NC
Magnesium, Total (s)	ug/L		65261	65281	1,500	1,470	1,490	2.0
Magnesium, Total (s)	ug/L		65269	65285	1,990	2,010	2,000	1.0
Magnesium, Dissolved (e) (s)	ug/L		65261	65281	1,460	1,460	1,460	0.0
Magnesium, Dissolved (e) (s)	ug/L		65269	65285	2,050	1,980	2,020	3.5
Manganese, Total (e) (s)	ug/L		65261	65281	12.3	12.1	12.2	1.6
Manganese, Total (e) (s)	ug/L		65269	65285	18.0	18.2	18.1	1.1

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Manganese, Dissolved (e) (s)	ug/L		65261	65281	14.2	12.5	13.4	13
Manganese, Dissolved (e) (s)	ug/L		65269	65285	19.1	19.5	19.3	2.1
Mercury, Total (s)	ug/L	P123	65261	65281	ND(0.017)	ND(0.017)	ND(0.017)	NC
Mercury, Total (s)	ug/L	P123	65269	65285	ND(0.017)	0.310	< 0.164	NC
Mercury, Dissolved (s)	ug/L	P123	65261	65281	0.250	0.290	0.270	15
Mercury, Dissolved (s)	ug/L	P123	65269	65285	0.270	0.390	0.330	36
Molybdenum, Total	ug/L		65261	65281	ND(1.50)	ND(1.50)	ND(1.50)	NC
Molybdenum, Total	ug/L		65269	65285	ND(1.50)	ND(1.50)	ND(1.50)	NC
Nickel, Total (s)	ug/L	P124	65261	65281	23.9	23.7	23.8	0.84
Nickel, Total (s)	ug/L	P124	65269	65285	14.2	15.0	14.6	5.5
Nickel, Dissolved (s)	ug/L	P124	65261	65281	23.6	23.3	23.5	1.3
Nickel, Dissolved (s)	ug/L	P124	65269	65285	14.8	15.0	14.9	1.3
Selenium, Total	ug/L	P125	65261	65281	ND(0.572)	0.600	< 0.586	NC
Selenium, Total	ug/L	P125	65269	65285	0.720	0.640	0.680	12
Selenium, Dissolved	ug/L	P125	65261	65281	ND(0.572)	0.640	< 0.606	NC
Selenium, Dissolved	ug/L	P125	65269	65285	0.810	0.800	0.805	1.2
Silver, Total	ug/L	P126	65261	65281	ND(1.28)	ND(1.28)	ND(1.28)	NC
Silver, Total	ug/L	P126	65269	65285	ND(1.28)	ND(1.28)	ND(1.28)	NC
Sodium, Total (e) (s)	ug/L		65261	65281	94,800	92,300	93,600	2.7

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Sodium, Total (e) (s)	ug/L		65269	65285	88,700	89,400	89,100	0.79
Sodium, Dissolved (e) (s)	ug/L		65261	65281	91,400	90,900	91,200	0.55
Sodium, Dissolved (e) (s)	ug/L		65269	65285	90,600	87,300	89,000	3.7
Thallium, Total (s)	ug/L	P127	65261	65281	ND(0.009)	ND(0.009)	ND(0.009)	NC
Thallium, Total (s)	ug/L	P127	65269	65285	ND(0.009)	ND(0.009)	ND(0.009)	NC
Thallium, Dissolved	ug/L	P127	65261	65281	ND(0.009)	ND(0.009)	ND(0.009)	NC
Thallium, Dissolved	ug/L	P127	65269	65285	ND(0.009)	ND(0.009)	ND(0.009)	NC
Tin, Total	ug/L		65261	65281	ND(3.45)	ND(3.45)	ND(3.45)	NC
Tin, Total	ug/L		65269	65285	ND(3.45)	ND(3.45)	ND(3.45)	NC
Tin, Dissolved	ug/L		65261	65281	ND(3.45)	ND(3.45)	ND(3.45)	NC
Tin, Dissolved	ug/L		65269	65285	ND(3.45)	ND(3.45)	ND(3.45)	NC
Titanium, Total (e)	ug/L		65261	65281	ND(0.253)	ND(0.253)	ND(0.253)	NC
Titanium, Total (e)	ug/L		65269	65285	ND(0.253)	ND(0.253)	ND(0.253)	NC
Titanium, Dissolved (e)	ug/L		65261	65281	ND(0.253)	0.380	< 0.317	NC
Titanium, Dissolved (e)	ug/L		65269	65285	0.340	ND(0.253)	< 0.297	NC
Vanadium, Total	ug/L		65261	65281	ND(0.679)	ND(0.679)	ND(0.679)	NC
Vanadium, Total	ug/L		65269	65285	ND(0.679)	ND(0.679)	ND(0.679)	NC
Vanadium, Dissolved	ug/L		65261	65281	ND(0.679)	ND(0.679)	ND(0.679)	NC
Vanadium, Dissolved	ug/L		65269	65285	ND(0.679)	ND(0.679)	ND(0.679)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-9) (b)	Duplicate Effluent from Treatment (SP-10) (b)	Average	Relative Percent Difference
Yttrium, Total	ug/L		65261	65281	ND(0.222)	ND(0.222)	ND(0.222)	NC
Yttrium, Total	ug/L		65269	65285	ND(0.222)	ND(0.222)	ND(0.222)	NC
Zinc, Total (e) (s)	ug/L	P128	65261	65281	553	545	549	1.5
Zinc, Total (e) (s)	ug/L	P128	65269	65285	320	346	333	7.8
Zinc, Dissolved (e) (s)	ug/L	P128	65261	65281	536	532	534	0.75
Zinc, Dissolved (e) (s)	ug/L	P128	65269	65285	329	316	323	4.0
Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	65265	65283	ND(10.0)	ND(10.0)	ND(10.0)	NC
Bis(2-ethylhexyl)phthalate	ug/L	P066	65277	65289	ND(10.0)	ND(10.0)	ND(10.0)	NC
Phenanthrene	ug/L	P081	65265	65283	ND(10.0)	ND(10.0)	ND(10.0)	NC
Phenanthrene	ug/L	P081	65277	65289	ND(10.0)	ND(10.0)	ND(10.0)	NC
Phenol	ug/L	P065	65265	65283	ND(10.0)	ND(10.0)	ND(10.0)	NC
Phenol	ug/L	P065	65277	65289	ND(10.0)	ND(10.0)	ND(10.0)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4

Field Duplicate Analytical Results for Pathogen Indicators, HEM/SGT-HEM, Volatile Organics, and Dioxins and Furans in Incinerator Ash, Holland America Veendam

Field duplicate analytical results for pathogen indicators, HEM/SGT-HEM, volatile organics, and dioxins and furans in incinerator ash. Field duplicate samples for these analytes were collected sequentially from the same source, stored and analyzed independently. See Figure 2-2 for the sampling point locations. Also listed are the average result and relative percent difference calculated for each duplicate pair. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Waste Stream	Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Influent to Treatment (SP-6/7) (b)	**Pathogen Indicators**								
	E. coli	MPN/100 mL		65224	65310	> 2,420,000	75,900	> 1,250,000	NC
	Enterococci	MPN/100 mL		65224	65310	> 2,420,000	201,000	> 1,310,000	NC
	Fecal Coliform	CFU/100 mL		65224	65310	14,500,000	3,600,000	9,050,000	120
	Classical Pollutants								
	Hexane Extractable Material (HEM)	mg/L		65227	65228	127	131	129	3.1
	Hexane Extractable Material (HEM)	mg/L		65231	65232	154	174	164	12
	Silica Gel Treated HEM (SGT-HEM)	mg/L		65227	65228	48.0	21.0	34.5	78
	Silica Gel Treated HEM (SGT-HEM)	mg/L		65231	65232	12.0	17.0	14.5	34
Influent to UV Disinfection (SP-8) (b)	**Pathogen Indicators**								
	E. coli	MPN/100 mL		65259	65304	75.4	77.1	76.3	2.2
	Enterococci	MPN/100 mL		65259	65304	60.8	35.4	48.1	53
	Fecal Coliform	CFU/100 mL		65259	65304	18.2	8.18	13.2	76

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Treatment (SP-9/10) (b)	**Pathogen Indicators**								
	E. coli	MPN/100 mL		65264	65302	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65267	65303	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65276	65311	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65279	65305	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65261	65281	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65265	65283	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65273	65287	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65274	65288	ND(1.00)	ND(1.00)	ND(1.00)	NC
	E. coli	MPN/100 mL		65277	65289	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Enterococci	MPN/100 mL		65264	65302	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Enterococci	MPN/100 mL		65267	65303	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Enterococci	MPN/100 mL		65276	65311	1.00	1.00	1.00	0.0
	Enterococci	MPN/100 mL		65279	65305	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Enterococci	MPN/100 mL		65261	65281	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Enterococci	MPN/100 mL		65265	65283	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Enterococci	MPN/100 mL		65273	65287	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Enterococci	MPN/100 mL		65274	65288	5.10	ND(1.00)	< 3.05	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Treatment (SP-9/10) (b)	Enterococci	MPN/100 mL		65277	65289	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65264	65302	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65267	65303	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65276	65311	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65279	65305	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65261	65281	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65265	65283	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65273	65287	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65274	65288	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Fecal Coliform	CFU/100 mL		65277	65289	ND(1.00)	ND(1.00)	ND(1.00)	NC
	Classical Pollutants								
	Hexane Extractable Material (HEM)	mg/L		65269	65270	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Hexane Extractable Material (HEM)	mg/L		65273	65274	ND(5.00)	ND(6.00)	ND(5.50)	NC
	Hexane Extractable Material (HEM)	mg/L		65277	65278	ND(6.00)	ND(6.00)	ND(6.00)	NC
	Silica Gel Treated HEM (SGT-HEM)	mg/L		65269	65270	ND(5.00)	ND(5.00)	ND(5.00)	NC
	Silica Gel Treated HEM (SGT-HEM)	mg/L		65273	65274	ND(5.00)	ND(6.00)	ND(5.50)	NC
	Silica Gel Treated HEM (SGT-HEM)	mg/L		65277	65278	ND(6.00)	ND(6.00)	ND(6.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Effluent from Treatment (SP-9/10) (b)	**Volatile Organics**								
	Tetrachloroethene	ug/L	P085	65265	65283	21.7	53.0	37.4	84
	Tetrachloroethene	ug/L	P085	65269	65285	39.4	56.0	47.7	35
	Trichloroethene	ug/L	P087	65265	65283	ND(10.0)	ND(10.0)	ND(10.0)	NC
	Trichloroethene	ug/L	P087	65269	65285	ND(10.0)	ND(10.0)	ND(10.0)	NC
Incinerator Ash (SP-13/14) (b)	**Dioxins and Furans**								
	1,2,3,4,6,7,8-HpCDD	pg/g		65293	65294	43.9	340	192	150
	1,2,3,4,6,7,8-HpCDF	pg/g		65293	65294	193	3,580	1,890	180
	1,2,3,4,7,8,9-HpCDF	pg/g		65293	65294	15.5	219	117	170
	1,2,3,4,7,8-HxCDD	pg/g		65293	65294	ND(10.0)	13.6	<11.8	NC
	1,2,3,4,7,8-HxCDF	pg/g		65293	65294	43.7	332	188	150
	1,2,3,6,7,8-HxCDD	pg/g		65293	65294	6.12	28.8	17.5	130
	1,2,3,6,7,8-HxCDF	pg/g		65293	65294	43.3	331	187	150
	1,2,3,7,8,9-HxCDD	pg/g		65293	65294	9.34	49.0	29.2	140
	1,2,3,7,8,9-HxCDF	pg/g		65293	65294	ND(10.0)	12.4	<11.2	NC
	1,2,3,7,8-PeCDD	pg/g		65293	65294	ND(10.0)	6.40	<8.20	NC
	1,2,3,7,8-PeCDF	pg/g		65293	65294	29.0	55.7	42.4	63
	2,3,4,6,7,8-HxCDF	pg/g		65293	65294	65.8	787	426	170

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-2 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-8 for source water results.
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit, or because one or both sample results is flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Waste Stream	Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original	Duplicate	Average	Relative Percent Difference
Incinerator Ash (SP-13/14) (b)	2,3,4,7,8-PeCDF	pg/g		65293	65294	53.4	206	130	120
	2,3,7,8-TCDD	pg/g		65293	65294	1.63	1.37	1.50	17
	2,3,7,8-TCDF	pg/g		65293	65294	37.6	32.8	35.2	14
	Octachlorodibenzo-p-dioxin	pg/g		65293	65294	73.4	780	427	170
	Octachlorodibenzofuran	pg/g		65293	65294	63.8	1,420	742	180

(a) - Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) - Sampling point location; see Figures 2-1 and 2-2.
NC - Not calculated because one or both of the sample results is less than and/or greater than the laboratory detection limit.
ND - Not detected (number in parenthesis is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Average result includes at least one result flagged by the laboratory as “>” because the sample was not diluted sufficiently.

6.0 REFERENCES

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