This document contains the 2004 Norwegian Star Sampling Episode Report for sampling episode 6504. The report and all the appendices can be downloaded from
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Norwegian Star

Sampling Episode Report

March 2006

United States Environmental Protection Agency

Sampling Episode Report
Norwegian Star
Sampling Episode 6504

U.S. Environmental Protection Agency

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ACKNOWLEDGMENT AND DISCLAIMER

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EXECUTIVE SUMMARY

Sampling Episode Report for Norwegian Star

This Sampling Episode Report describes the sampling and analysis activities to characterize wastewater (graywater and sewage) generated and discharged by the cruise vessel Norwegian Star while in Alaska waters. This sampling took place from August 8 through August 13, 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 Norwegian Star to characterize the performance of the Scanship wastewater treatment system, an advanced wastewater treatment system that uses aerobic biological oxidation followed by dissolved air flotation and ultraviolet (UV) disinfection. Samples were collected of various wastewater sources (galley, food pulper, accommodations, and laundry wastewater), influent to the treatment system (combined graywater and sewage), influent to the UV disinfection component of the treatment system, effluent from the treatment system, source water, wastewater treatment sludge, and incinerator ash. Wastewater samples were collected for five consecutive 24-hour sampling periods, except for food pulper wastewater samples, which were collected for a single 24-hour sampling period.

Strap-on ultrasonic flow meters were installed near the sampling locations for the galley wastewater, accommodations wastewater, laundry wastewater, influent to treatment, and effluent from treatment to collect flow data and to trigger automatic sampling machines.

Various sample collection methods (composite by flow, grab, and grab composite) were used depending on the sampling point and the 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 enterococci, oil and grease, nutrients, and solids. Galley wastewater samples had the highest concentration for 14 of the tested analytes, including *E. coli*, toluene, and several metals. Laundry and accommodations wastewater samples showed the highest concentrations for only 5 and 4 analytes, respectively.

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 Star wastewater treatment system than in typical domestic wastewater. Of the 54 metal analytes tested for, 28 were detected in every influent to treatment system sample. Among the 377 target analytes for volatile and semivolatile organics, pesticides, and polychlorinated biphenyls, only 8 were detected in any Star influent to treatment samples, most at concentrations close to their detection limits.

The Scanship treatment system successfully removed almost all pathogen indicators (>99%) and most classical pollutants, metals, and organics. Two pathogen indicators, enterococci and *E. coli*, were not detected in any of the 15 effluent treatment samples, while one indicator, fecal coliform, was detected in 2 samples. The treatment system removed almost all BOD_5 (99%), COD (93%), total organic carbon (TOC) (94%), settleable residue (>99%) and TSS (99%). The treatment system reduced total phosphorus by 98%. Ammonia and total Kjeldahl nitrogen (TKN) results for this sampling episode were anomalous; therefore, EPA is unable to assess the performance of the Scanship treatment system for these analytes. The treatment system was highly efficient at removing particulate metals, and removed dissolved metals at an average of 50%. The treatment system removed most of the volatile and semivolatile organics to concentrations below detection levels.

The Scanship wastewater treatment system generates waste biosludge (excess biological mass from the treatment system's bioreactor). 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 the waste biosludge were also detected in the influent to the treatment system. The presence of these constituents in waste biosludge suggests that these analytes are removed from the system in these waste streams.

On average, each person generated approximately 59 gallons of untreated sewage and graywater per day. The average discharge from the treatment system was also approximately 59 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 Norwegian Cruise Line's cruise ship Star (Star) while in Alaska waters. This sampling episode took place from August 8 through August 13, 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 Star is a 91,740 gross-ton cruise vessel launched in 2001. The vessel has 15 decks, a length of 965 feet, and a beam of 105 feet. The Star's maximum cruising speed is 25 knots. Its port of registry is Nassau, Bahamas. During the sampling episode, the Star carried 2,591 passengers and 1,144 crew. The ship's itinerary was as follows:

Date	Port
August 8, 2004	Seattle, Washington
August 9, 2004	Cruising Inside Passage
August 10, 2004	Juneau, Alaska
August 11, 2004	Skagway, Alaska
August 12, 2004	Cruising Glacier Bay
August 13, 2004	Ketchikan, Alaska
August 14, 2004	Victoria, 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 standards 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).

EPA selected the Star to characterize the performance of the Scanship Environmental AS (Tønsberg, Norway) wastewater treatment system (Scanship treatment system), an advanced wastewater treatment system that uses aerobic biological oxidation followed by dissolved air flotation and ultraviolet disinfection. EPA will use the analytical and flow data included in this sampling episode report to evaluate the performance of the Scanship treatment system, and to analyze patterns and variability in wastewater sources.

Samples were in accordace with procedures 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 the Star* (Star SAP). The Star 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 indictor analyses were performed on board. 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 Star, 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 Star 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 Star, as well as the sample collection points and flow meter locations and installation points used in this sampling episode.

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. Norwegian Cruise Lines 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. Note that certain information has been removed from this section to protect material for which a claim of confidential business information (CBI) has been made. The confidential version of this report can be found in the confidential portion of the Cruise Ship Rulemaking Record.

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 Scanship treatment system or to overboard discharge. 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 Star's graywater and sewage CHT system. (Figure 2-1 has been redacted to prevent disclosure of material for which a claim of CBI has been made.) 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 seldom bunkered while in port.

2.2 Wastewater Treatment

The Star is outfitted with a Scanship treatment system, an advanced wastewater treatment system that uses aerobic biological oxidation followed by dissolved air flotation and ultraviolet (UV) disinfection. Figure 2-2 is a simplified diagram of the Scanship treatment system. (Figure 2-2 has been modified to prevent disclosure of material for which a claim of CBI has been made.)

Wastewater from the galley, accommodations, laundry, and sewage CHT subsystems combine in one graywater and sewage holding tank. (Note that food pulper wastewater is not routed to the graywater and sewage holding tank, but instead is discharged without treatment outside 12 nm from shore.) The combined wastewater is then pumped through two coarse drum filters operated in parallel (mesh size 0.5mm) and then through two aerated bioreactors operated in series. Each bioreactor contains free floating plastic beads to support biological growth. Operators add a defoaming agent to the bioreactors. Following aeration and biodegradation in the bioreactors, the wastewater is pumped to two dissolved air flotation (DAF) units operated in parallel to separate solids. Anionic polymer and flocculant (polyaluminum chloride) are added to the wastewater to aid the flotation process.

From the DAF units, the wastewater is pumped to two polishing screen filters operated in parallel (mesh size 0.03 mm). In the final stage of treatment, the wastewater undergoes UV disinfection in three parallel UV units for destruction of bacteria and viruses. The UV units are cleaned approximately every three weeks using Metalbrite solutions containing 80% water and 20% phosphoric acid. The Metalbrite solution is reused until spent.

According to the ship's crew, the Scanship treatment system can treat 1,400 m^3 (370,000 gallons) per day of wastewater generated onboard. This is well in excess of its typical daily load, approximately 840 m^3 (222,000 gallons), as determined based on measured flows collected during this sampling episode.

The Scanship 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. Where overboard discharge is prohibited, such as in Glacier National Park, treated wastewater is diverted to storage in double-bottom holding tanks and held for eventual discharge overboard outside 12 nautical miles (nm). Treated wastewater storage capacity totals 1,437 m3.

Treated wastewater is recycled back to the treatment system when effluent TSS concentrations exceed 27 mg/L (determined based on a correlation to measured effluent turbidity) to ensure that inadequately treated wastewater is not discharged.

The Scanship treatment system generates two types of residual waste: coarse drum filter solids and DAF solids (excess biomass from the bioreactors). These residuals are routed to the solids holding tank. Figure 2-3 is a diagram of the Star treatment residual handling system. (Figure 2-3 has been redacted to prevent disclosure of material for which a claim of CBI has been made.) The maximum wet solids generation rate is 25 m^3 per day. The combined residuals are dewatered using a centrifuge followed by a press to increase the solids content to over 20%. The dewatered solids are dried further in a dryer to over 60% dryness and then incinerated onboard. Incinerator ash is disposed of on shore as a non-hazardous waste. Wastewater generated from solids dewatering is returned to the graywater and sewage holding tank at the start of the Scanship treatment system.

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 residual; 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 residual and

incinerator ash sampled. In general, graywater and influent to and effluent from the treatment system samples were taken for five 24-hour periods, while samples of food pulper wastewater and wastewater treatment residual were taken for one 24-hour period. 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 five sampling locations to collect flow data and to control automatic composite sample machines (by triggering collection after a defined amount of flow passed through the pipe). The first location was on the discharge line from the galley wastewater holding tank (galley wastewater, SP-1; see Table 2-1 for a description of wastewaters and Figure 2-1 for a simplified graywater and sewage CHT system diagram showing sampling points and flow meter locations). The second location was on the discharge line from one of the fourteen accommodations wastewater collection tanks (accommodations wastewater, SP-3; see Table 2-1 and Figure 2-1). The third location was laundry wastewater (SP-4; see Table 2-1 and Figure 2-1); this flow meter was installed on the discharge line from the laundry wastewater holding tank. The fourth flow meter location was at the influent to the wastewater treatment system on the inlet pipe to the two coarse drum filters

(SP-5; see Table 2-1 and Figure 2-2). The final location was at the effluent from the wastewater treatment system (on the overboard discharge line for the treated effluent, SP-7/8; see Table 2-1 and Figure 2-2).

Flow estimates for the food pulper wastewater were provided by the ship's crew.

Table 2-1

Wastewater, Sampling Point, and Flow Meter Descriptions, Norwegian Star

Descriptions of wastewaters sampled, sampling point locations, flow meter locations, and number of days sampled for the Star sampling episode (August 8 through August 13, 2004). Note that certain information has been removed from this table to prevent disclosure of material for which a claim of CBI has been made.

Wastewater Name	Wastewater Description(a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Galley	Wastewater from the ship's galley.	SP-1	Sample tap was installed on the discharge line from the galley wastewater holding tank.	Strap-on flow meter was installed on the discharge line from the galley wastewater holding tank (the same discharge line as the installed sample tap).	5
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 pulper wastewater is routed to a food pulper wastewater holding tank for recirculation back to the Somat system. Food pulper wastewater is disposed of at sea outside 12 nm.	SP-2	Samples were collected from a sample tap located on the food pulper wastewater holding tank.	Flow measurements not required. Approximately 10 m^3 of food pulper wastewater is generated per day, according to the ship's crew.	1 (Day 3)
Accommodations	Wastewater from sinks, tubs, and showers in guest and crew accommodations.	SP-3	Sample tap was installed on the discharge line from one of several collection tanks. According to the ship's crew, all accommodations collection tanks receive similar wastewater; therefore, the specific collection tank sampled was selected based on accessibility.	Strap-on flow meter was installed on the discharge line from one of the accommodations collection tanks (the same discharge line as the installed sample tap).	5
Laundry	Wastewater from the ship's laundry.	SP-4	Sample tap was installed on the discharge line from the laundry wastewater holding tank.	Strap-on flow meter was installed on the discharge line from the laundry wastewater holding tank (the same discharge line as the installed sample tap).	5

(a) List of wastewater sources may not be comprehensive.
(b) See Figures 2-1 and 2-2 for simplified diagrams of the Star graywater and sewage CHT and 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 5-4 and 5-5 for details on duplicate sampling.

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 Scanship Treatment System	Combined wastewaters from four collection, holding, and transfer (CHT) subsystems (laundry, accommodations, galley, sewage). Does not include food pulper wastewater, which is discharged without treatment. A vacuum CHT system conveys sewage from passenger and crew toilets and urinals. Gamazyme is added to the toilets as a biological cleaner. Note that samples were not taken directly from the sewage CHT system. Sewage and graywater combine in the graywater and sewage holding tank, which is the first component of the Scanship treatment system.	SP-5	Sample tap was installed on the combined wastewater inlet pipe to the treatment system (before the coarse drum filters).	Strap-on flow meter was installed on the inlet pipe to the coarse drum filters (the same discharge line as the installed sample tap).	5
Influent to UV Disinfection Part of Scanship Treatment System	Wastewater following treatment by biological oxidation, dissolved air filtration, and polishing screen filtration but prior to UV disinfection.	SP-6	Sample tap was installed on the wastewater transfer pump to the UV disinfection unit.	Flow measurements were not required.	5
Effluent from Treatment	Final treated wastewater effluent from the Scanship 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-7/8	Sample tap was installed on the overboard discharge pipe following UV disinfection.	Strap-on flow meter was installed on the overboard discharge pipe following UV disinfection (the same discharge line as the installed sample tap).	5
Source Water	Potable water used as source water for all systems that generate wastewater that is treated by the Scanship treatment system.	SP-11	Samples collected from the bathroom sink in a sampling team member's cabin.	Flow measurements were not required.	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 Star graywater and sewage CHT and 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 5-4 and 5-5 for details on duplicate sampling.

Table 2-2

Treatment Residual and Incinerator Ash Descriptions, Norwegian Star

Descriptions of treatment residuals and incinerator ash sampled, sampling point locations, flow meter locations, and number of days sampled for the Star sampling episode (August 8 through August 13, 2004). Note that certain information has been removed from this table to prevent disclosure of material for which a claim of CBI has been made.

Treatment Residual Name	Treatment Residual Description	Sampling Point # (a)	Sampling Point Description (a)	Flow Meter Description	# of Days Sampled
Dried Wastewater Treatment Sludge	Combined Scanship treatment residuals (coarse drum filter solids and dissolved air flotation solids) that are dewatered and dried.	SP-9	Sample was collected from the dried sludge screw feeder to the incinerator.	Flow measurements not required. Approximately 25 m^3 of wet treatment sludge are generated per day according to the ship's crew.	1 (Day 1)
Incinerator Ash	Ash generated from the incineration of trash (e.g., cardboard, paper, plastic) and dried wastewater treatment sludge. Incinerator ash is collected in incinerator ash storage hoppers for disposal onshore.	SP-10	Samples were collected directly from an incinerator ash storage hopper.	Flow measurements not required.	2 (Day 1 and Day 4)

(a) See Figure 2-3 for simplified diagram of the Star's wastewater treatment residual handling system indicating the sampling point locations.

Figure 2-1 has been redacted to prevent disclosure of material for which a claim of confidential business information has been made.

Figure 2-1. Graywater and Sewage Collection, Holding and Transfer System, Norwegian Star

Simplified diagram of the Norwegian Star graywater and sewage CHT system. See Table 2-1 for a list of wastewater streams in each wastewater source.

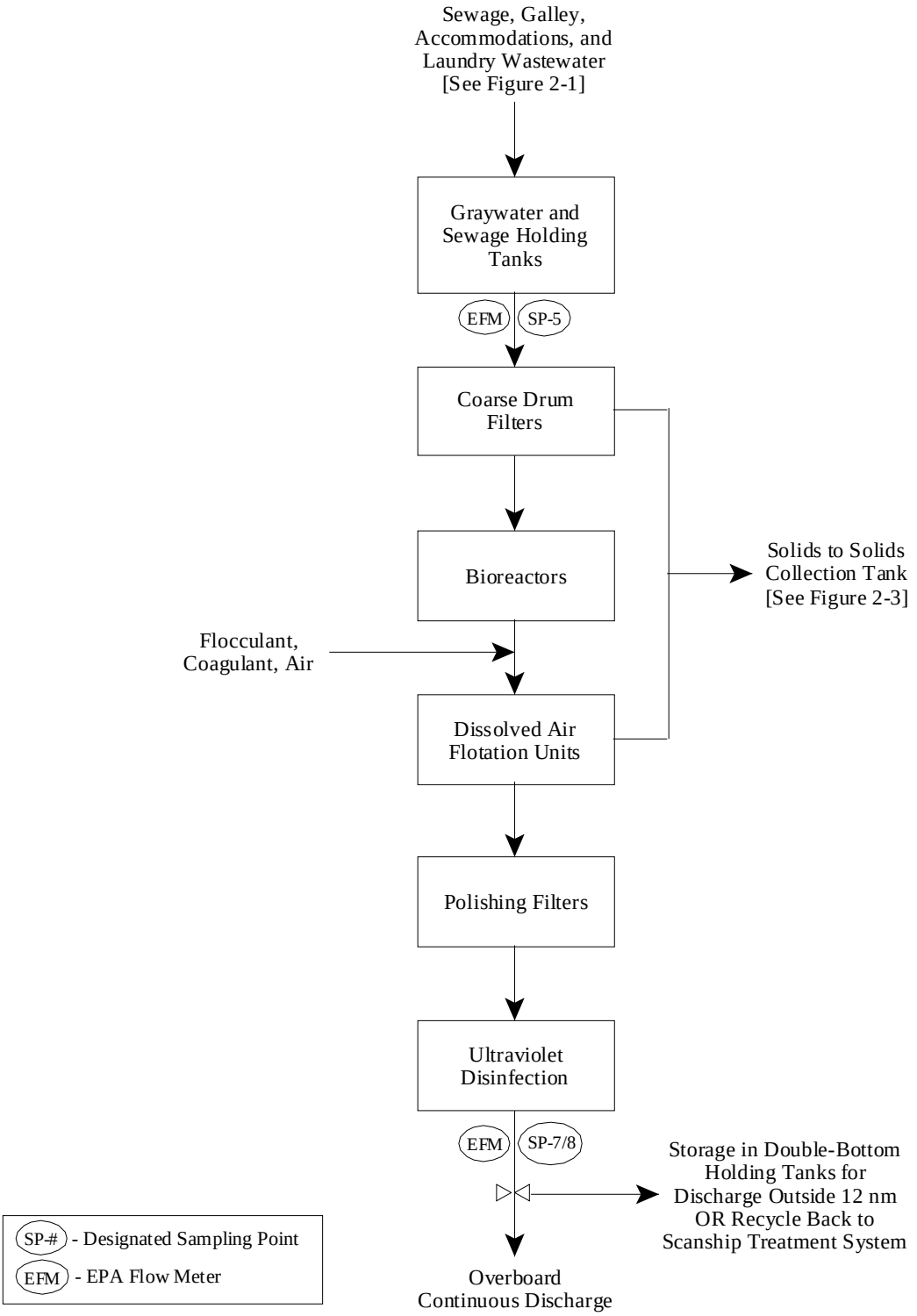

Figure 2-2. Scanship Treatment System, Norwegian Star

Simplified diagram of the Norwegian Star Scanship 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. Note that Figure 2-2 has been modified to prevent disclosure of material for which a claim of CBI has been made.

Figure 2-3 has been redacted to prevent disclosure of material for which a claim of confidential business information has been made.

Figure 2-3. Sewage/Graywater Treatment Residual Handling, Norwegian Star

Simplified diagram of the Norwegian Star sewage/graywater treatment residual handling system. See Table 2-2 for descriptions for the treatment residuals and Figure 2-2 for their points of generation by the Scanship 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 Norwegian Star (Star 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 Star can be found in Section 3.0 of the Star SAP.

3.1 Pre-Sampling Activities

EPA performed an egineering ship visit to the Star on May 18, 2004. The Star SAP was prepared based on information collected during that ship visit and from subsequent follow-up communication with Norwegian personnel. One week prior to the sampling episode, personnel conducted sampling setup activities onboard the Star, 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 Methodologies

In general, samples of graywater, influent to and effluent from the treatment system were taken for five consecutive 24-hour periods, while food pulper and wastewater treatment residual samples were taken for one 24-hour period, (see Tables 2-1 and 2-2). Various sample collection methods (described in Table 3-1) were used depending on the wastewater and the 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 3) 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 onboard. Temperature and pH were measured immediately at the sampling point, and the remaining parameters were measured at the sample staging area onboard. 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 Star SAP (Appendix E), with the exception noted in Section 3.5 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 the strap-on flow meters installed by the sampling team. See Section 2.4 for descriptions of the flow meter locations and Figures 2-1 and 2-2 for their locations. The flow meters were programmed to record the instantaneous flow rate (m^3/min) and total flow (m^3) every five minutes. Flow data recorded by the Star's pre-existing in-line flow meter could not be printed or downloaded for presentation and analysis in this report.

3.3 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 5-4 and 5-5 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.

3.4 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.

3.5 Deviations from the Sampling and Analysis Plan

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

Table 3-1

Sample Collection Method Descriptions, Norwegian Star

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 for 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.
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). The sampling team prepared composite HEM/SGT-HEM samples onboard for a single analysis per sampling point per day by filling 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.

Table 3-2

Sample Collection Methods and Analyte Groups Tested by Sampling Point, Norwegian Star

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Galley	SP-1	**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	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 Two grab samples were taken per sampling day. Results presented in Table 4-1 are an average for each sampling day. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	
Food Pulper	SP-2	**Grab composite** The collection times of the four subsamples in the composite sample can be found in Appendix A-3.	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 One grab sample was taken. Appendix A-1 shows the collection time.	Pathogen indicators	

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

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Accommodations	SP-3	**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 The collection times of the four subsamples in the composites 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: 1, 2, 2, 2, 2. 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	
Laundry	SP-4	**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 Dioxins and furans	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 Two grab samples were taken per sampling day. Results presented in Table 4-4 are an average for each sampling day. Results and collection times for each grab sample are presented in Appendix A-1.	Pathogen indicators	

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

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Influent to Scanship Treatment System	SP-5	**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 for 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: 3, 2, 3 ,3, 3. Results presented in Table 4-6 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 Scanship Treatment System	SP-6	**Grab** Three grab samples were taken per sampling day. Results presented in Table 4-7 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, 2-2, and 2-3 for simplified diagrams of the Star graywater and sewage CHT, wastewater treatment, and wastewater treatment residual handling systems indicating the sampling point locations.
(b) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 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.

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Effluent from Scanship Treatment System	SP-7/ 8	**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 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 Three grab samples were taken per sampling day. Results presented in Table 4-8 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	
Dried Wastewater Treatment Sludge	SP-9	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Classical pollutants: - Group I - Group II - Total and available cyanide Total metals Volatile and semivolatile organics	1 (Day 1)
Incinerator Ash	SP-10	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Total metals Semivolatile organics Dioxins and furans	2 (Day 1 and Day 4)

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

Table 3-2 (Continued)

Wastewater Name	Sampling Point # (a)(b)	Sample Collection Methods (c)	Analyte Groups Tested (d)	# of Days Sampled
Source Water	SP-11	**Grab** One grab sample was taken. Appendix A-3 shows the collection time.	Pathogen indicators Classical pollutants: - BOD_5 - Settleable residue - Group I - Group II - Total and available cyanide Total and dissolved metals Volatile and semivolatile organics	1 (Day 4)
Trip Blank	SP-12	**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 Star. The trip blank was shipped back (unopened) to the laboratory along with the collected samples.	Volatile organics	1 (Day 3)
Equipment Blank	SP-13	**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 (Day 2)

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

Table 3-3

Analytes and Analytical Methods, Norwegian Star

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, Lloyd Kahn (“solids” sample) EPA 410.4 EPA 350.3 EPA 353.1 EPA 351.3 EPA 365.2
	Oil and grease measured as hexane extractable material and petroleum hydrocarbons measured as silica-gel treated hexane extractable material (HEM/SGT-HEM)	EPA 1664A
	Cyanide - Total cyanide - Available cyanide	 EPA 335.2 EPA 1677
	Hardness	SM 2340B
Total and Dissolved Metals	See Appendix A-2 for complete list of metals analyzed.	EPA 200.7, EPA 200.9 (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, Norwegian Star

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, Norwegian Star

Deviation	Description
Pathogen Indicators Sample Collection	To conserve laboratory capacity, one rather than two grab samples of food pulper wastewater (a complex matrix with high solids content) was collected for pathogen indicators analyses. Additionally, one accommodations grab sample was missed due to lack of flow, and one influent to treatment grab sample was missed due to sampling error.
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 5-5 for details on duplicate sampling for pathogen indicators.
Galley Wastewater (SP-1) Sampling Point Location	The galley wastewater sampling point and flow meter location was not properly identified during the pre-sampling ship visit; however, the correct location was identified and used during the sampling episode. The new sampling location was a dedicated galley wastewater transfer pump, and the flow meter was installed on the transfer pump's discharge pipe.
Food Pulper Wastewater (SP-2) Sampling Point Location	During the sampling episode, the sampling team determined that the sampling point location for the food pulper wastewater would not provide a representative sample. The original sampling point was located on a discharge pump from the food pulper wastewater holding tank. However, the discharge pump and discharge piping for this holding tank was not dedicated to food pulper wastewater (other wastewater streams, including sewage, were also discharged through the pump and piping). The food pulper wastewater samples were instead collected from one of the food pulper wastewater recirculation tanks; therefore, food pulper wastewater samples were not collected as discharged but as generated.
Accommodations Wastewater (SP-3) Tank Cleaning	The ship's crew cleaned the wastewater collection tank from which accommodations wastewater samples were being collected during the second day of sampling. The automatic sampling machine was paused during the cleaning activities.
Incinerator Ash (SP-10) Sample Collection	An incinerator ash sample was collected on Day 1; however, dried wastewater treatment sludge was not fed to the incinerator at that time because the centrifuge used for sludge dewatering was not working properly. A replacement incineration ash sample was collected on Day 4 when the Star resumed incineration of dried wastewater treatment sludge.
Volatile Organics Preservation	Free chlorine was detected in pre-sampling 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 Star SAP.)

Table 3-5 (Continued)

Deviation	Description
Analytical Methods	EPA-contracted laboratories substituted comparable EPA analytical methods for certain analytes. Table 3-3 lists the actual analytical methods used by the laboratories. Note that while the Star SAP correctly listed EPA Methods 624 and 625 as the planned methods for analyzing volatile and semivolatile organics, respectively, Appendix E of the Star 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 Star 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.

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 ammonia, total Kjeldahl nitrogen (TKN), and available and total cyanide; these data have not been excluded from the data set, but the results are presented and discussed in Sections 5.1.1 and 5.1.2 (in the data quality section of this report) and not in the current section. During the 2005 cruise season, EPA conducted a supplementary sampling program to collect additional ammonia and TKN data to better assess these analytes in cruise ship wastewater (see Section 5.1.2).

4.1 Laboratory Analytical Results and Discussion

4.1.1 Graywater

Tables 4-1 through 4-4 present analytical results for galley, food pulper, accommodations, and laundry wastewaters, respectively. Table 4-5 compares the average analyte concentrations for these four graywater sources. Samples of the galley, accommodations, and laundry wastewater were collected for five consecutive 24-hour sampling periods during the sampling episode, while samples of food pulper wastewater were collected for only one 24-hour sampling 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 289 analytes tested for in the graywater sources, 71 were detected in these waste streams. Thirteen of these 71 analytes were also detected at some level in the equipment blank (flagged by an “e” in Tables 4-1 through 4-5; see Table 5-3 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. Twenty-four of these 73 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 Tables 4-1 through 4-5; see Table 4-12 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			
	Galley	Food Pulper	Accommodations	Laundry
Pathogen Indicators	3	3	3	3
Classical Pollutants	14	13	13	12
Total and Dissolved Metals	42	41 (b)	31	33
Volatile and Semivolatile Organics	5	2	3	5
Total	**64**	**59**	**50**	**53**

(a) See Table 3-3 for information on analyte groups.
(b) Sample results for total and dissolved sodium were excluded. See Section 5.1 for details.

Chart 2 presents the number of analytes that were detected in each graywater source at the highest average concentration. For example, the highest average *E. coli* concentration was found in the galley wastewater, the highest average enterococci concentration was found in the food pulper wastewater, and the highest average fecal coliform concentration 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 Average Concentration in Graywater

Analyte Group (a)	Number of Analytes Detected in Graywater	Number of Analytes Detected at the Highest Average Concentration			
		Galley	Food Pulper	Accommodations	Laundry
Pathogen Indicators	3	1	1	1	0
Classical Pollutants	14	0	12	1	1
Total and Dissolved Metals	48	12	33	1	2
Volatile and Semivolatile Organics	6	1	2	1	2
Total	**71**	**14**	**48**	**4**	**5**

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

Galley wastewater contained a total of 64 analytes and showed the highest average concentration for 14 analytes, including *E. coli*, toluene, and several metals. Galley wastewater showed the second highest average concentration for several analytes commonly used to measure wastewater strength: enterococci, fecal coliform, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), hexane extractable material (HEM) and silica-gel treated hexane extractable material (SGT-HEM), total suspended solids (TSS). The galley wastewater was the only graywater source that was analyzed for pesticides because this was the most likely possible source; none were detected. *E.coli* and fecal coliform levels increased by 3 and 4 orders of magnitude, respectively, from Day 1 through Day 5. According to Norwegian Cruise Line, extensive ship cleaning and sanitation that occurs on "turn-around" day (Day 1) reduces bacterial levels in the galley wastewater collection tank

While galley wastewater contained the greatest number of detected analytes, food pulper wastewater contained the greatest number of analytes detected at the highest average concentration (48 out of 71 detected analytes). Food pulper wastewater had the highest average concentrations of enterococci, almost all classical pollutants (including HEM and SGT-HEM, BOD_5, COD, total organic carbon (TOC), phosphorus, and solids), and most metals.

Accommodations wastewater contained a total of 50 analytes and showed the highest average concentration for fecal coliform, nitrate/nitrite, total thallium, and diethyl phthalate. E. coli and fecal coliform levels increase significantly from Day 1 through Day 5.

Like galley wastewater, Norwegian Cruise Line believes extensive ship cleaning and sanitation on Day 1 reduces bacteria levels in the accommodations wastewater collection tanks.

Laundry wastewater contained a total of 53 analytes and showed the highest average concentration for alkalinity, total and dissolved copper, bromodichloromethane, and chloroform. The 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.

4.1.2 Influent to Treatment System

Table 4-6 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 14 classical pollutants were detected in the influent to treatment samples. One of these 17 analytes–hardness–was also detected at some level in the equipment blank (flagged by an "e" in Table 4-6; see Table 5-3 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 4-6; see Table 4-12 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples. Note that anomalous analytical results were obtained for ammonia and total Kjeldahl nitrogen; and the results are presented and discussed in Section 5.1.2.

Wastewater conservation practices used onboard, such as use of vacuum toilets, result in highly concentrated wastewater. Chart 3 compares the influent to the Star treatment system to typical domestic wastewater for selected pathogen indicators and classical pollutants. Fecal coliform and enterococci concentrations in the influent to the Scanship 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 Star Treatment System to Untreated Domestic Wastewater

Parameter	Untreated Star Wastewater	Untreated Domestic Wastewater (a)
Enterococci	10^5 MPN/100 mL	10^2 to 10^3 number/100 mL
Fecal Coliform	10^7 to 10^8 CFU/100 mL	10^4 to 10^5 number/100 mL
Biological Oxygen Demand (BOD_5)	651 to 979 mg/L	110 to 400 mg/L
Chemical Oxygen Demand (COD)	344 to 1,020 mg/L	250 to 1,000 mg/L
Nitrate/Nitrite	0.0330 to 0.0800 mg/L	0 mg/L
Oil and Grease	85.0 to 103 mg/L	50 to 150 mg/L
Total Phosphorus	13.6 to 29.6 mg/L	4 to 15 mg/L
Total Suspended Solids (TSS)	300 to 573 mg/L	100 to 350 mg/L

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

Total and Dissolved Metals

Of the 34 metal analytes detected in the influent to treatment samples, 28 were detected in every influent to treatment sample (Table 4-6). Thirteen of these 34 analytes were detected at some level in the equipment blank (flagged by an "e" in Table 4-6; see Table 5-3 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. Seventeen 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 4-6; see Table 4-12 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 aluminum, total and dissolved calcium, total and dissolved iron, total and dissolved magnesium, and total and dissolved sodium. Total and dissolved chromium, total and dissolved copper, total mercury, total and dissolved nickel, and total and dissolved zinc 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 carbon steel and stainless steel pipes and tanks in the ship.

Volatile and Semivolatile Organics, Pesticides, PCBs

Among the 377 target analytes for volatile and semivolatile organics, dioxins and furans, pesticides, and chlorinated biphenyls, only 8 were detected in any Star influent to treatment samples: 1 volatile organic, 3 semivolatile organics, and 4 PCBs (Table 4-6). Many of these analytes were detected at concentrations close to their detection limits. None of the 3 detected semivolatile organics were detected in the equipment blank (see Table 5-3 for equipment blank results; volatile organics and PCBs were not analyzed for in the equipment blank). EPA will consider the impact of possible contamination from sampling equipment in a future analysis.

The three semivolatile organics detected in the influent to treatment were: bis(2-ethylhexyl)phthalate, diethyl phthalate, and phenol. Bis(2-ethylhexyl)phthalate and diethyl phthalate are plasticizers (chemicals added to plastics to make them flexible) and are commonly detected in environmental samples (ATSDR, 2002 and ATSDR, 1996). 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 these plasticisers in the influent to treatment.

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. Phenol was also detected in the source water (see Table 4-12 for source water results) meaning that the source water may have contributed some or all of this analyte to the sample.

The one volatile analyte detected in the influent to treatment was chloroform. Chloroform is a disinfection by-product (U.S. EPA, 1998); however, lack of detection of chloroform in source water (Table 4-12) and detection of chloroform in laundry wastewater (Table 4-4) indicate that laundry operations rather than source water disinfection are the likely source of chloroform in the influent to treatment.

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

Four PCB congeners and co-eluting congener groups were detected in the influent to the wastewater treatment system: PCB-11, PCB-16, PCB-129+PCB-138+PCB-160+PCB-163, and PCB-153+PCB-168. In addition, the laboratory reported total dichloro biphenyls, total hexachloro 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 2.5 times the detection limit. None of the detected PCBs were among the 14 “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 4-7 presents pathogen indicator results for the influent to UV disinfection part of the Star’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 4-6), were reduced by four orders of magnitude after the bioreactor and dissolved air flotation (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 4-8 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 two grab samples, one on each of Days 1 and 2, with fecal coliform detected.

Eleven of the 14 classical pollutants were detected in effluent from treatment system; 3 classical pollutants (HEM, settleable residue, and SGT-HEM) were not detected in any effluent samples. One of the 11 detected classical analytes–hardness–was also detected at some level in the equipment blank (flagged by an "e" in Table 4-8; see Table 5-3 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. Five 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 4-8; see Table 4-12 for source water results), meaning that the source water may have contributed some or all of these analytes to the samples. Note that anomalous analytical results were obtained for ammonia; these results are presented and discussed in Section 5.1.2.

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

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

Classical Pollutant	Average Effluent from Star Treatment System	Secondary Treatment Standards (a)
Biochemical Oxygen Demand (BOD_5)	6.96 mg/L	45 mg/L
Total Suspended Solids (TSS)	<5.30 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).

Total and Dissolved Metals

Among the 54 total and dissolved metal analytes tested for, 27 were detected in one or more effluent from treatment samples (Table 4-8). Of these 27 detected metal analytes, 20 were detected in every effluent from treatment sample. Eleven of the 27 detected metal analytes were also detected at some level in the equipment blank (flagged by an "e" in Table 4-8; see Table 5-3 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. Seventeen of these detected metal 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 4-8; see Table 4-12 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 aluminum, total iron, and total and dissolved calcium, magnesium, sodium, and zinc. Total and dissolved copper, total and dissolved nickel, and total and dissolved zinc 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 80 target analytes for volatile and semivolatile organics analyzed, only one–phenol–was detected in any Star effluent samples (Table 4-8). Phenol was detected in the source water (flagged by an "s" in Table 4-8; see Table 4-12 for source water results), meaning that the source water may have contributed some or all of the detected phenol to the effluent samples.

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 Scanship treatment system successfully removed almost all pathogen indicators (>99%; Table 4-9) and most classical pollutants, metals, and organics (Table 4-10).

Pathogen Indicators and Classical Pollutants

Pathogen indicators are removed by four orders of magnitude by the combination of biological degradation and dissolved air flotation/polishing filtration. Remaining pathogen indicators were generally removed by UV disinfection to levels below detection (overall system efficiency >99%, see Table 4-9). Enterococci and *E. coli* were not detected in any of the 15 effluent from treatment samples; fecal coliform 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%), chemical oxygen demand (COD) (93%), and total organic carbon (TOC) (94%) (Table 4-10). The system also removed almost all settleable residue and total suspended solids (TSS) (99% or greater). Oils and greases (HEM) were removed to levels below detection.

The treatment system reduced total phosphorus by 98%. Phosphorus is most likely taken up by the microorganisms in the bioreactors as evidenced by elevated total phosphorus concentrations in the dried wastewater treatment sludge (see Section 4.1.6 and Table 4-11). Ammonia and TKN results for this sampling episode were anomalous; therefore, EPA is unable to assess the performance of the Scanship treatment system for these analytes at this time (see Section 5.1.2). During the 2005 cruise season, EPA conducted a supplementary sampling program to collect additional performance data for ammonia (see Section 5.1.2).

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 4-6). In comparison, metals are 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 for most metals analytes) (Table 4-8). Furthermore, there were elevated metals concentrations in the dried wastewater treatment sludge (see Table 4-11). This means that the treatment system is highly efficient in removing particulate metals, as would be expected for a dissolved air filtration/polishing filtration system (and as supported by 99% removal of settleable residue and TSS, see Table 4-10). The treatment system removed dissolved metals with an average efficiency of 50% (Table 4-10).

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 4-10). Possible removal mechanisms include biological degradation, adsorption onto wastewater treatment sludge (see Table 4-11), 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 Scanship 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 Wastewater Treatment Sludge and Incinerator Ash

Table 4-11 presents the results for analytes detected in one-time grab samples of dried wastewater treatment sludge (coarse drum filter solids and excess biological mass from the treatment system's bioreactors) and incinerator ash (from incineration of trash) collected during the sampling episode. Table 4-11 also shows the average influent to treatment analyte concentrations from Table 4-10 for comparison. Note that a replacement incinerator ash sample was collected on Day 4 because the original incinerator ash sample collected on Day 1 did not include incineration of dried wastewater treatment sludge (see Table 3-5 for more information). Results for the ash sample collected on Day 1 are presented in Appendix A-2.

Most of the analytes detected in the dried wastewater treatment sludge were also detected in the influent to treatment. These data suggest that these analytes are removed from the system in the treatment residuals. 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 is seldom bunkered while in port. Five classical pollutants, 9 total metals, 8 dissolved metals, and 1 semivolatile organic were detected in the one-time grab sample of potable water collected during this sampling episode (Table 4-12). None of the analytes detected in the source water exceeded Federal drinking water standards (Table 4-12). Pathogen indicators were not detected in the source water sample.

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 Star has two main dining rooms, eight additional restaurants, and 24-hour room service. Approximately 15,000 meals (breakfast, lunch, dinner, and snacks) are served daily. The ship's 9 galleys are equipped with six automatic washing machines (dishwashers, glass washer, pot washers). Dishwashers are located in all galleys and operated during and after each meal. The dishwasher in one small, 24-hour galley is operated as needed. Dishes are washed using Dip It XP, Solid Power, Super Trump, or Balanced Fusion (high-alkaline solid automatic dishmachine detergents). The impact of the caustic component of the dishwashing detergent is minimal as the pH of the sampled galley wastewater was approximately 5. Other galley cleaning products include Greasecutter Plus (high alkaline liquid oven cleaner/degreaser), Lime-A-Way (high muriatic acid liquid cleaner/delimer), manual pot/pan and dishwashing detergents, general all purpose cleaners, bleach, and liquid hand cleaner. The galley floor drains are cleaned once per week using Gamazyme biological cleaner. Material Safety Data Sheets (MSDS) for these products are included in the Cruise Ship Rulemaking Record and are available upon request. Table 4-13 lists the galley cleaning agents and their ingredients.

Laundry

The Star laundry typically operates 12 hours per day except the day before change-over days (i.e., when the ship disembarks passengers and embarks new passengers) when it operates longer. Operating hours are approximately 1100 to 2300 each day. Flow data confirms laundry wastewater generation between noon and midnight. The Star has eight large machines (50 liters of water used per load) that process approximately 15 loads per day and two small machines (25 liters of water used per load) that process approximately six loads per day. The laundry uses six cleaning agents that are auto-dosed to each washing machine. Additionally, there are five crew launderettes with approximately six small washers in each.

Photo Processing

The Star has an onboard photo processing lab. All waste photographic chemicals are collected into polyethylene containers for disposal onshore. Silver-containing chemicals are pretreated by a silver recovery unit, which retains the silver within the filter for eventual recovery. The filtrate is collected into a container that is offloaded for disposal as either hazardous or nonhazardous waste depending on the tested silver content. The photo lab has no floor drains to ensure spilled chemicals do not enter the drain system. The photo lab has one sink for hand washing, and the sink discharges to the graywater system.

Print Shop

The Star houses a print shop in which solvents, activators, stabilizers, and inks are used. Rags and wipes containing solvents are disposed of onshore as hazardous waste. Residual activators, stabilizers, and inks are disposed of onshore as hazardous waste two times a year. The print shop sink is used for hand washing and diluting chemicals for use. The sink drains to the graywater system. The shop has no waste treatment facilities.

Dry Cleaning

The Star has a self-contained dry cleaning machine with an internal distilling/ recycling unit for low annual usage of perchloroethylene. Management of dry cleaning wastewater (condensate separator water) was not verified; however, perchloroethylene was not detected in any wastewater samples.

Chemical Storage

The ship has several chemical storage areas onboard, all of which are locked. Store rooms on Decks 3 and 4 house hotel chemicals such as detergents, bleach, and metal cleaning products. Acids, alkalines, and reactives are stored in separate areas. Some storage rooms include small dikes for containment, and there are no floor drains or sinks. Degreasers, defoamers, paints, water treatment chemicals, and other chemicals specified for "industrial use" are stored in the engine room. Any spills from the storage areas in the engine room drain into the bilge. Bilge compartments are generally segregated, and the ship can pump all bilge compartments. Material Safety Data Sheets are maintained for all chemicals.

4.2.2 Pesticide, Fungicide, and Rodenticide Use

Ship areas including storage rooms, food preparation corridors, crew cabin corridors, laundry rooms, garbage rooms, galleys, and pantries are inspected for pests on a weekly basis and treated with Siege Gel insecticide (active ingredient hydramethylnon) for controlling pests (typically cockroaches) on a monthly basis. Other areas are inspected and treated as necessary upon request. The Siege Gel insecticide is kept in a storage room with a floor drain and a sink that drain to the graywater system. No pesticides were detected in Star wastewater samples.

The Star uses insect light traps to lure and capture flies on an adhesive trapping board. The Star does not use fungicides or rodenticides onboard.

4.3 Flow Data

Strap-on ultrasonic flow meters were used to collect flow measurements and to control automatic composite sample machines on (1) the outlet from the galley wastewater transfer pump, (2) the outlet from 1 of the 14 accommodations wastewater collection tanks, (3) the outlet from the laundry wastewater holding tank, (4) the influent to wastewater treatment, and (5) the effluent from wastewater treatment (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. Flow data analyses presented in this section are based on only those flow data collected during the sampling episode of August 8 through August 13. Appendix B presents all flow data collected while onboard the Star from August 2 through August 13.

The Star has an in-line Siemens flow meter installed on the inlet pipe to the drum filters (sampling point SP-5), the same location as the strap-on flow meter installed on the influent to wastewater treatment (see Figure 2-2). However, flow data recorded from the in-line flow meter could not be printed or downloaded from the Scanship control system for presentation and analysis in this report. During the installation of the strap-on influent flow meter, the flow readings of the in-line and installed flow meters showed excellent agreement.

The total daily volume of galley wastewater, accommodations wastewater (one collection tank only), laundry wastewater, influent to the treatment system, and effluent from the treatment system for each 24-hour sampling period are presented in Figure 4-1. The total daily flow from the accommodations and laundry remained relatively constant over the five-day sampling period, regardless of whether the ship was in port (Days 1, 3, and 4) or at sea (Days 2 and 5). The galley wastewater and influent to and effluent from treatment flows were more variable.

Daily flow rates and flow per capita are presented in Table 4-14. Per capita flow rates were calculated based on 3,735 people (2,591 passengers and 1,144 crew) onboard during the sampling episode, as reported by the ship's crew. (Per capita volumes of accommodations wastewater generated were not calculated because the flow for only one collection tank was monitored.) On average, each person generated approximately 59 gallons of untreated sewage

and graywater per day during the sampling episode. The average discharge from the treatment system was also approximately 59 gallons of treated wastewater per person per day. The ship's crew estimates that graywater sources contribute approximately 95% to the total influent to treatment flow, while sewage makes up the remainder.

Figure 4-2 presents the average flow for effluent from treatment for each hour interval over the five consecutive 24-hour sampling periods. The effluent flows range from approximately 30 to 41 m^3 per hour. Higher flows during the morning may be due to increased passenger activities (e.g., generation of accommodation wastewater); the accommodations wastewater flow peaks at 0700. Higher flows during the evening and early morning may be due to laundry and galley operations; galley wastewater flow peaks at 2200, and laundry wastewater flow peaks at 0100.

Table 4-1

Galley Wastewater Analytical Results, Norwegian Star

Analytical results for galley wastewater 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). Galley wastewater samples were collected for five consecutive 24-hour periods; see Section 3.2 for the sample collection methodology. Table 2-1 lists the specific wastewater streams in galley wastewater, and Figure 2-1 identifies the sampling point location. Average galley wastewater concentrations determined from the daily results. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Units	Priority Pollutant Code	Galley (SP-1) (a) Day 1	Galley (SP-1) (a) Day 2	Galley (SP-1) (a) Day 3	Galley (SP-1) (a) Day 4	Galley (SP-1) (a) Day 5	Average Galley (SP-1)(a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		# 12,100[N=2]	> 131,000[N=2]	> 242,000[N=2]	1,440,000[N=2]	> 12,200,000[N=2]	# 2,800,000
Enterococci (b)	MPN/100 mL		> 12,300[N=2]	5,150[N=2]	19,800[N=2]	4,250[N=2]	6,820[N=2]	>9,650
Fecal Coliform (b)	CFU/100 mL		> 4,500[N=2]	> 600,000[N=1]	> 600,000[N=1]	2,500,000[N=1]	54,000,000[N=2]	> 11,500,000
Classical Pollutants								
Alkalinity	mg/L		ND(10.0)	37.0	27.0	81.0	37.0	<38.4
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		3,210	1,650	1,460	2,220	4,290	2,570
Chemical Oxygen Demand (COD)	mg/L		1,900	1,060	1,100	1,460	1,690	1,440
Chloride (s)	mg/L		95.0	95.0	95.0	75.0	75.0	87.0
Hardness (e) (s)	mg/L		48.3	28.4	39.2	64.1	51.8	46.4
Hexane Extractable Material (HEM)	mg/L		113	337	348	122	157	215

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). Results are reported as an average for each 24-hour 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.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-1 (Continued)

Analyte	Units	Priority Pollutant Code	Galley (SP-1) (a) Day 1	Galley (SP-1) (a) Day 2	Galley (SP-1) (a) Day 3	Galley (SP-1) (a) Day 4	Galley (SP-1) (a) Day 5	Average Galley (SP-1)(a)
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		ND(0.0100)	0.0180	0.0390	0.0530	0.0280	<0.0296
Settleable Residue	mL/L		170 mL/L	7.50 mL/L	4.30 mL/L	63.0 mL/L	37.0 mL/L	56.4
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(4.00)	ND(4.00)	60.0	ND(5.00)	ND(5.00)	<15.6
Sulfate	mg/L		35.1	17.0	4.49	14.4	11.9	16.6
Total Dissolved Solids (TDS) (s)	mg/L		937	646	552	748	676	712
Total Organic Carbon (TOC)	mg/L		645	252	298	437	297	386
Total Phosphorus	mg/L		73.0	24.8	44.0	38.0	28.1	41.6
Total Suspended Solids (TSS)	mg/L		2,450	676	716	1,650	2,260	1,550
Total and Dissolved Metals								
Aluminum, Total	ug/L		50,200	6,400	15,500	52,800	5,850	26,200
Antimony, Total	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Total	ug/L	P115	2.67	ND(2.00)	ND(2.00)	2.54	ND(2.00)	<2.24
Barium, Total (e) (s)	ug/L		44.5	8.97	12.4	33.2	31.8	26.2
Beryllium, Total	ug/L	P117	0.740	ND(0.0700)	ND(0.0700)	0.480	ND(0.0700)	<0.286
Boron, Total	ug/L		149	510	296	342	653	390
Cadmium, Total	ug/L	P118	0.910	ND(0.0800)	0.370	0.620	0.290	<0.454
Calcium, Total (s)	ug/L		12,500	6,650	8,700	16,800	14,000	11,700

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). Results are reported as an average for each 24-hour 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.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-1 (Continued)

Analyte	Units	Priority Pollutant Code	Galley (SP-1) (a) Day 1	Galley (SP-1) (a) Day 2	Galley (SP-1) (a) Day 3	Galley (SP-1) (a) Day 4	Galley (SP-1) (a) Day 5	Average Galley (SP-1)(a)
Chromium, Total	ug/L	P119	24.4	10.3	8.41	10.2	24.8	15.6
Cobalt, Total	ug/L		0.860	ND(0.660)	0.740	1.07	ND(0.660)	<0.798
Copper, Total (e) (s)	ug/L	P120	572	194	259	546	467	408
Iron, Total (e) (s)	ug/L		1,890	765	981	1,530	1,720	1,380
Lead, Total (e)	ug/L	P122	6.21	2.78	3.39	4.43	ND(0.620)	<3.49
Magnesium, Total (s)	ug/L		4,170	2,870	4,240	5,410	4,120	4,160
Manganese, Total (e) (s)	ug/L		51.5	16.6	21.3	39.7	31.5	32.1
Mercury, Total	ug/L	P123	0.220	ND(0.0500)	0.110	0.170	0.110	<0.132
Molybdenum, Total	ug/L		2.22	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	<1.72
Nickel, Total (e) (s)	ug/L	P124	22.6	12.0	12.2	14.6	22.7	16.8
Selenium, Total	ug/L	P125	2.60	ND(1.40)	ND(1.40)	3.40	2.70	<2.30
Silver, Total	ug/L	P126	1.43	1.14	ND(0.770)	1.33	1.32	<1.20
Sodium, Total (s)	ug/L		69,900	84,500	69,000	89,800	93,700	81,400
Thallium, Total	ug/L	P127	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)
Tin, Total (e)	ug/L		27.1	8.82	14.4	20.4	15.7	17.3
Titanium, Total	ug/L		6.25	2.16	3.05	4.14	6.58	4.44
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	1.52	0.630	<0.712
Yttrium, Total	ug/L		0.380	ND(0.310)	ND(0.310)	0.330	ND(0.310)	<0.328

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). Results are reported as an average for each 24-hour 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.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
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Table 4-1 (Continued)

Analyte	Units	Priority Pollutant Code	Galley (SP-1) (a) Day 1	Galley (SP-1) (a) Day 2	Galley (SP-1) (a) Day 3	Galley (SP-1) (a) Day 4	Galley (SP-1) (a) Day 5	Average Galley (SP-1)(a)
Zinc, Total (e) (s)	ug/L	P128	668	335	475	572	449	500
Aluminum, Dissolved	ug/L		13,300	1,820	1,580	1,790	2,250	4,150
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		7.84	0.910	2.77	5.51	11.0	5.61
Boron, Dissolved (e)	ug/L		159	567	350	393	795	453
Cadmium, Dissolved	ug/L	P118	ND(0.0800)	0.320	ND(0.0800)	ND(0.0800)	0.200	<0.152
Calcium, Dissolved (s)	ug/L		13,300	5,810	8,610	12,800	13,700	10,800
Chromium, Dissolved	ug/L	P119	1.88	1.99	1.32	1.13	2.33	1.73
Cobalt, Dissolved (s)	ug/L		4.37	8.88	0.710	4.90	7.38	5.25
Copper, Dissolved (s)	ug/L	P120	1.55	103	45.0	42.4	117	61.8
Iron, Dissolved	ug/L		1,060	530	545	496	955	717
Lead, Dissolved	ug/L	P122	ND(0.620)	ND(0.620)	ND(0.620)	1.35	2.94	<1.23
Magnesium, Dissolved (s)	ug/L		4,200	3,000	4,600	4,630	4,520	4,190
Manganese, Dissolved (e) (s)	ug/L		13.8	21.1	10.8	18.6	22.8	17.4
Molybdenum, Dissolved	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Dissolved (s)	ug/L	P124	11.4	8.22	9.16	8.45	12.6	9.97
Selenium, Dissolved	ug/L	P125	ND(1.40)	1.52	ND(1.40)	ND(1.40)	ND(1.40)	<1.42

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). Results are reported as an average for each 24-hour 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.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
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Table 4-1 (Continued)

Analyte	Units	Priority Pollutant Code	Galley (SP-1) (a) Day 1	Galley (SP-1) (a) Day 2	Galley (SP-1) (a) Day 3	Galley (SP-1) (a) Day 4	Galley (SP-1) (a) Day 5	Average Galley (SP-1)(a)
Sodium, Dissolved (s)	ug/L		90,100	98,600	89,400	84,600	107,000	93,900
Tin, Dissolved	ug/L		1.13	2.84	2.10	ND(0.940)	ND(0.940)	<1.59
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (e)	ug/L	P128	428	292	311	248	342	324
Volatile and Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	370	43.0	260	340	800	363
Bromodichloromethane	ug/L	P048	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Chloroform	ug/L	P023	7.00	ND(5.00)	6.00	ND(5.00)	8.00	<6.20
Diethyl Phthalate	ug/L	P070	ND(10.0)	32.0	ND(10.0)	ND(10.0)	ND(10.0)	<14.4
Phenol (s)	ug/L	P065	58.0	72.0	35.0	39.0	43.0	49.4
Toluene	ug/L	P086	9.00	11.0	13.0	24.0	12.0	13.8

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). Results are reported as an average for each 24-hour 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.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-2

Food Pulper Wastewater Analytical Results, Norwegian Star

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

Analyte	Unit	Priority Pollutant Code	Food Pulper (SP-2) (a)
Pathogen Indicators			
E. coli	MPN/100 mL		> 24,200
Enterococci	MPN/100 mL		> 24,200
Fecal Coliform	CFU/100 mL		170,000
Classical Pollutants			
Alkalinity	mg/L		ND(10.0)
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		52,300
Chemical Oxygen Demand (COD)	mg/L		26,800
Chloride (s)	mg/L		1,100
Hardness (e) (s)	mg/L		402
Hexane Extractable Material (HEM)	mg/L		688
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.120
Settleable Residue	mL/L		1,000
Silica Gel Treated HEM (SGT-HEM)	mg/L		220
Sulfate	mg/L		41.2
Total Dissolved Solids (TDS) (s)	mg/L		6,710
Total Organic Carbon (TOC)	mg/L		1,560
Total Phosphorus	mg/L		308
Total Suspended Solids (TSS)	mg/L		29,400
Total and Dissolved Metals			
Aluminum, Total	ug/L		1,460
Antimony, Total	ug/L	P114	7.05
Arsenic, Total	ug/L	P115	18.7
Barium, Total (e) (s)	ug/L		66.5
Beryllium, Total	ug/L	P117	ND(0.0700)
Boron, Total	ug/L		453
Cadmium, Total	ug/L	P118	2.54
Calcium, Total (s)	ug/L		119,000

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
ND - Not detected (number in parentheses is detection limit).
> - 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	Food Pulper (SP-2) (a)
Chromium, Total	ug/L	P119	26.4
Cobalt, Total	ug/L		2.34
Copper, Total (e) (s)	ug/L	P120	312
Iron, Total (e) (s)	ug/L		1,570
Lead, Total (e)	ug/L	P122	7.90
Magnesium, Total (s)	ug/L		25,400
Manganese, Total (e) (s)	ug/L		340
Mercury, Total	ug/L	P123	0.680
Molybdenum, Total	ug/L		11.2
Nickel, Total (e) (s)	ug/L	P124	27.9
Selenium, Total	ug/L	P125	41.5
Silver, Total	ug/L	P126	ND(0.770)
Sodium, Total (s)			EXCLUDE
Thallium, Total	ug/L	P127	1.48
Tin, Total (e)	ug/L		113
Titanium, Total	ug/L		4.43
Vanadium, Total	ug/L		ND(0.470)
Yttrium, Total	ug/L		ND(0.310)
Zinc, Total (e) (s)	ug/L	P128	987
Aluminum, Dissolved	ug/L		876
Antimony, Dissolved	ug/L	P114	7.79
Arsenic, Dissolved	ug/L	P115	14.9
Barium, Dissolved (e) (s)	ug/L		71.7
Boron, Dissolved (e)	ug/L		586
Cadmium, Dissolved	ug/L	P118	0.150
Calcium, Dissolved (s)	ug/L		171,000
Chromium, Dissolved	ug/L	P119	5.37
Cobalt, Dissolved (s)	ug/L		29.5
Copper, Dissolved (s)	ug/L	P120	23.9
Iron, Dissolved	ug/L		629
Lead, Dissolved	ug/L	P122	ND(0.620)
Magnesium, Dissolved (s)	ug/L		29,300
Manganese, Dissolved (e) (s)	ug/L		46.2

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
ND - Not detected (number in parentheses is detection limit).
> - 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	Food Pulper (SP-2) (a)
Molybdenum, Dissolved	ug/L		6.01
Nickel, Dissolved (s)	ug/L	P124	28.2
Selenium, Dissolved	ug/L	P125	27.0
Sodium, Dissolved (s)			EXCLUDE
Tin, Dissolved	ug/L		18.7
Vanadium, Dissolved	ug/L		0.660
Zinc, Dissolved (e)	ug/L	P128	634
Volatile and Semivolatile Organics			
Bis(2-ethylhexyl)phthalate	ug/L	P066	1,600
Bromodichloromethane	ug/L	P048	ND(10.0)
Chloroform	ug/L	P023	ND(10.0)
Diethyl Phthalate	ug/L	P070	ND(50.0)
Phenol (s)	ug/L	P065	100
Toluene	ug/L	P086	ND(10.0)

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in the equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
ND - Not detected (number in parentheses is detection limit).
> - 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

Accommodations Wastewater Analytical Results, Norwegian Star

Analytical results for accommodations wastewater for analytes detected at least once in wastewater samples during the sampling episode. See Appendices A-1 and A-1 for all analytical results (detected and nondetected). Accommodations wastewater samples were collected for five consecutive 24-hour periods; see Section 3.2 for the sample collection methodology. Table 2-1 lists the specific wastewater streams in accommodations wastewater, and Figure 2-1 identifies the sampling point location. Average accommodations wastewater 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	Accommodations (SP-3)(a) Day 1	Accommodations (SP-3)(a) Day 2	Accommodations (SP-3)(a) Day 3	Accommodations (SP-3)(a) Day 4	Accommodations (SP-3)(a) Day 5	Average Accommodations (SP-3)(a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		> 24,200[N=1]	> 242,000[N=2]	> 242,000[N=2]	> 484,000[N=2]	535,000[N=2]	>305,000
Enterococci (b)	MPN/100 mL		ND(1.00)[N=1]	# 1,220[N=2]	< 25.5[N=2]	< 80.0[N=2]	229[N=2]	#310
Fecal Coliform (b)	CFU/100 mL		> 6,000[N=1]	> 3,000,000[N=2]	> 600,000[N=1]	48,000,000[N=1]	43,500,000[N=2]	>19,000,000
Classical Pollutants								
Alkalinity	mg/L		17.0	28.0	32.0	38.0	57.0	34.4
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		223	145	264	71.1	71.7	155
Chemical Oxygen Demand (COD)	mg/L		203	177	103	76.0	75.0	127
Chloride (s)	mg/L		35.0	55.0	45.0	25.0	25.0	37.0
Hardness (e) (s)	mg/L		22.2	28.1	24.8	34.6	40.5	30.0
Hexane Extractable Material (HEM)	mg/L		38.0	41.0	46.0	20.0	31.0	35.2
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.130	0.130	0.110	0.0760	0.170	0.123

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Accommodations (SP-3)(a) Day 1	Accommodations (SP-3)(a) Day 2	Accommodations (SP-3)(a) Day 3	Accommodations (SP-3)(a) Day 4	Accommodations (SP-3)(a) Day 5	Average Accommodations (SP-3)(a)
Settleable Residue	mL/L		ND(0.110)	ND(0.100)	ND(0.100)	0.110	0.610	<0.206
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(9.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.80)
Sulfate	mg/L		42.0	45.2	38.3	4.70	15.3	29.1
Total Dissolved Solids (TDS) (s)	mg/L		143	162	142	110	127	137
Total Organic Carbon (TOC)	mg/L		70.8	44.8	37.2	20.1	21.9	39.0
Total Phosphorus	mg/L		1.85	3.25	2.44	2.41	3.73	2.74
Total Suspended Solids (TSS)	mg/L		56.0	71.0	63.0	38.0	66.0	58.8
Total and Dissolved Metals								
Aluminum, Total	ug/L		181 ug/L	109	124	ND(8.80)	163	<117
Antimony, Total	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		5.50	3.91	2.94	9.44	26.0	9.56
Beryllium, Total	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Total	ug/L		23.2	60.1	135	ND(18.0)	ND(18.0)	<50.9
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Total (s)	ug/L		5,750	5,530	5,030	8,910	12,100	7,460
Chromium, Total	ug/L	P119	4.09	4.72	2.59	1.29	1.75	2.89
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Accommodations (SP-3)(a) Day 1	Accommodations (SP-3)(a) Day 2	Accommodations (SP-3)(a) Day 3	Accommodations (SP-3)(a) Day 4	Accommodations (SP-3)(a) Day 5	Average Accommodations (SP-3)(a)
Copper, Total (e) (s)	ug/L	P120	151	188	118	153	224	167
Iron, Total (e) (s)	ug/L		943	267	184	194	474	412
Lead, Total (e)	ug/L	P122	3.91	4.78	2.99	ND(0.620)	ND(0.620)	<2.58
Magnesium, Total (s)	ug/L		1,910	3,480	2,960	3,000	2,490	2,770
Manganese, Total (e) (s)	ug/L		6.57	5.25	4.06	3.68	5.00	4.91
Mercury, Total	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	0.0780	<0.0556
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (e) (s)	ug/L	P124	10.9	8.23	6.30	7.20	9.22	8.37
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Silver, Total	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium , Total(s)	ug/L		14,300	29,900	24,100	18,300	15,800	20,500
Thallium, Total	ug/L	P127	ND(8.00)	ND(8.00)	ND(0.800)	0.830	ND(0.800)	<3.69
Tin, Total (e)	ug/L		ND(0.940)	1.53	ND(0.940)	1.19	ND(0.940)	<1.11
Titanium, Total	ug/L		0.880	1.42	0.680	4.95	1.99	1.98
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Yttrium, Total	ug/L		ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)
Zinc, Total (e) (s)	ug/L	P128	286	389	347	317	275	323
Aluminum, Dissolved	ug/L		101	58.6	ND(8.80)	26.8	39.5	<46.9
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Accommodations (SP-3)(a) Day 1	Accommodations (SP-3)(a) Day 2	Accommodations (SP-3)(a) Day 3	Accommodations (SP-3)(a) Day 4	Accommodations (SP-3)(a) Day 5	Average Accommodations (SP-3)(a)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		4.30	2.53	1.65	7.01	22.3	7.56
Boron, Dissolved (e)	ug/L		33.9	65.6	144	ND(18.0)	ND(18.0)	<55.9
Cadmium, Dissolved	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Dissolved (s)	ug/L		6,230	5,390	4,820	8,060	11,600	7,220
Chromium, Dissolved	ug/L	P119	1.40	1.82	1.58	0.870	0.380	1.21
Cobalt, Dissolved (s)	ug/L		4.24	4.45	0.820	ND(0.660)	0.880	<2.21
Copper, Dissolved (s)	ug/L	P120	94.9	90.5	64.3	84.6	111	89.1
Iron, Dissolved	ug/L		827	134	97.8	85.3	156	260
Lead, Dissolved	ug/L	P122	ND(0.620)	ND(0.620)	ND(0.620)	1.59	1.16	<0.922
Magnesium, Dissolved (s)	ug/L		2,280	4,210	3,270	2,950	2,610	3,060
Manganese, Dissolved (e) (s)	ug/L		11.9	10.2	4.85	4.05	5.07	7.21
Molybdenum, Dissolved	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Dissolved (s)	ug/L	P124	11.3	8.11	5.93	7.06	8.13	8.11
Selenium, Dissolved	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Sodium, Dissolved (s)	ug/L		18,300	38,300	28,300	16,400	15,300	23,300
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (e)	ug/L	P128	194	232	235	250	180	218

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-3 (Continued)

Analyte	Unit	Priority Pollutant Code	Accommodations (SP-3)(a) Day 1	Accommodations (SP-3)(a) Day 2	Accommodations (SP-3)(a) Day 3	Accommodations (SP-3)(a) Day 4	Accommodations (SP-3)(a) Day 5	Average Accommodations (SP-3)(a)
Volatile and Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	38.0	39.0	35.0	28.0	36.0	35.2
Bromodichloromethane	ug/L	P048	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Chloroform	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Diethyl Phthalate	ug/L	P070	28.0	30.0	26.0	21.0	21.0	25.2
Phenol (s)	ug/L	P065	ND(10.0)	ND(10.0)	55.0	51.0	40.0	<33.2
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-4

Laundry Wastewater Analytical Results, Norwegian Star

Analytical results for laundry wastewater 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). Laundry wastewater samples were collected for five consecutive 24-hour periods; see Section 3.2 for the sample collection methodology. Table 2-1 lists the specific wastewater streams in laundry wastewater, and Figure 2-1 identifies the sampling point location. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Laundry (SP-4)(a) Day 1	Laundry (SP-4)(a) Day 2	Laundry (SP-4)(a) Day 3	Laundry (SP-4)(a) Day 4	Laundry (SP-4)(a) Day 5	Average Laundry (SP-4)(a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		ND(1.00)[N=2]	3.10[N=2]	ND(1.00)[N=2]	ND(1.00)[N=2]	ND(1.00)[N=2]	<1.42
Enterococci (b)	MPN/100 mL		ND(1.00)[N=2]	< 1.00[N=2]	# 1,210[N=2]	ND(1.00)[N=2]	<1.00[N=2]	#243
Fecal Coliform (b)	CFU/100 mL		901[N=2]	> 3,010[N=2]	> 60,000[N=1]	ND(10.0)[N=1]	<60.0[N=2]	#12,800
Classical Pollutants								
Alkalinity	mg/L		45.0	51.0	48.0	58.0	89.0	58.2
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		111	83.2	70.5	59.8	103	85.5
Chemical Oxygen Demand (COD)	mg/L		183	144	134	139	171	154
Chloride (s)	mg/L		35.0	25.0	25.0	45.0	35.0	33.0
Hardness (e) (s)	mg/L		17.4	20.4	17.8	21.5	25.9	20.6
Hexane Extractable Material (HEM)	mg/L		17.0	23.0	12.0	13.0	20.0	17.0
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0650	0.150	0.100	0.0700	0.0800	0.0930
Settleable Residue	mL/L		ND(0.130)	ND(0.140)	ND(0.100)	ND(0.110)	ND(0.110)	ND(0.118)
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(4.00)	ND(4.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(4.60)
Sulfate	mg/L		37.6	33.8	33.8	13.4	22.4	28.2
Total Dissolved Solids (TDS) (s)	mg/L		171	171	140	225	264	194
Total Organic Carbon (TOC)	mg/L		41.1	36.7	48.7	40.9	52.1	43.9

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). 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=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one value flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-4)(a) Day 1	Laundry (SP-4)(a) Day 2	Laundry (SP-4)(a) Day 3	Laundry (SP-4)(a) Day 4	Laundry (SP-4)(a) Day 5	Average Laundry (SP-4)(a)
Total Phosphorus	mg/L		7.35	5.44	6.87	8.06	10.1	7.56
Total Suspended Solids (TSS)	mg/L		41.0	29.0	26.0	26.0	29.0	30.2
Total and Dissolved Metals								
Aluminum, Total	ug/L		174	116	112	188	145	147
Antimony, Total	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		33.5	34.4	26.9	29.4	28.1	30.5
Beryllium, Total	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Total	ug/L		30.3	34.9	28.4	ND(18.0)	ND(18.0)	<25.9
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	0.210	ND(0.0800)	ND(0.0800)	<0.106
Calcium, Total (s)	ug/L		3,920	5,190	4,220	4,870	6,350	4,910
Chromium, Total	ug/L	P119	2.94	1.62	2.53	1.30	1.72	2.02
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	520	666	471	493	326	495
Iron, Total (e) (s)	ug/L		194	163	83.0	117	114	134
Lead, Total (e)	ug/L	P122	3.41	2.22	1.52	ND(0.620)	ND(0.620)	<1.68
Magnesium, Total (s)	ug/L		1,860	1,810	1,760	2,260	2,440	2,030
Manganese, Total (e) (s)	ug/L		4.71	4.88	3.65	4.07	3.60	4.18
Mercury, Total	ug/L	P123	0.0530	0.0770	ND(0.0500)	ND(0.0500)	ND(0.0500)	<0.0560
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (e) (s)	ug/L	P124	3.93	3.64	2.91	2.45	2.63	3.11
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). 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=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one value flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-4)(a) Day 1	Laundry (SP-4)(a) Day 2	Laundry (SP-4)(a) Day 3	Laundry (SP-4)(a) Day 4	Laundry (SP-4)(a) Day 5	Average Laundry (SP-4)(a)
Silver, Total	ug/L	P126	0.810	ND(0.770)	0.830	ND(0.770)	ND(0.770)	<0.790
Sodium, Total (s)	ug/L		25,800	29,700	30,200	41,300	50,100	35,400
Thallium, Total	ug/L	P127	ND(8.00)	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)	ND(2.24)
Tin, Total (e)	ug/L		ND(0.940)	ND(0.940)	2.04	1.82	0.950	<1.34
Titanium, Total	ug/L		0.740	ND(0.620)	ND(0.620)	0.630	0.640	<0.650
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Yttrium, Total	ug/L		ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)
Zinc, Total (e) (s)	ug/L	P128	944	601	222	244	266	455
Aluminum, Dissolved	ug/L		94.0	67.1	ND(8.80)	98.9	86.8	<71.1
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		31.9	33.8	30.1	34.3	29.9	32.0
Boron, Dissolved (e)	ug/L		43.4	63.5	29.9	ND(18.0)	ND(18.0)	<34.6
Cadmium, Dissolved	ug/L	P118	ND(0.0800)	0.140	ND(0.0800)	ND(0.0800)	ND(0.0800)	<0.0920
Calcium, Dissolved (s)	ug/L		4,390	6,080	5,510	6,100	7,360	5,890
Chromium, Dissolved	ug/L	P119	1.20	0.900	1.73	0.980	1.01	1.16
Cobalt, Dissolved (s)	ug/L		0.970	3.32	2.76	2.61	2.15	2.36
Copper, Dissolved (s)	ug/L	P120	529	707	563	607	358	553
Iron, Dissolved	ug/L		146	85.9	48.4	77.8	72.1	86.0
Lead, Dissolved	ug/L	P122	ND(0.620)	ND(0.620)	ND(0.620)	1.82	2.15	<1.17
Magnesium, Dissolved (s)	ug/L		2,230	2,230	2,300	2,930	2,910	2,520
Manganese, Dissolved (e) (s)	ug/L		5.23	8.42	6.70	7.20	5.36	6.58

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). 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=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one value flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Laundry (SP-4)(a) Day 1	Laundry (SP-4)(a) Day 2	Laundry (SP-4)(a) Day 3	Laundry (SP-4)(a) Day 4	Laundry (SP-4)(a) Day 5	Average Laundry (SP-4)(a)
Molybdenum, Dissolved	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Dissolved (s)	ug/L	P124	3.41	3.36	2.49	2.82	2.61	2.94
Selenium, Dissolved	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Sodium, Dissolved (s)	ug/L		31,600	36,500	39,600	50,500	55,800	42,800
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (e)	ug/L	P128	851	617	263	308	283	464
Volatile and Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	51.0	110	25.0	73.0	48.0	61.4
Bromodichloromethane	ug/L	P048	ND(5.00)	ND(5.00)	5.00	ND(5.00)	ND(5.00)	<5.00
Chloroform	ug/L	P023	31.0	49.0	85.0	100	120	77.0
Diethyl Phthalate	ug/L	P070	15.0	17.0	10.0	ND(10.0)	ND(10.0)	<12.4
Phenol (s)	ug/L	P065	110	84.0	50.0	48.0	37.0	65.8
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)

(a) Sampling point location; see Figure 2-1.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with two grab samples per 24-hour sampling period (some pathogen indicator results were excluded; see Section 5.1). 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=2]). See Appendix A-1 for all individual grab sample results.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one value flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-5

Average Graywater Analytical Results, Norwegian Star

Average analytical results for each graywater source determined from the daily results presented in Tables 4-1 through 4-4. See Appendices A-1 and A-2 for all analytical results (detected and nondetected). Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Unit	Priority Pollutant Code	Galley (SP-1)(a)	Food Pulper (SP-2)(a)	Accommodations (SP-3)(a)	Laundry (SP-4)(a)
Pathogen Indicator						
E. coli	MPN/100 mL		#2,800,000	>24,200	>305,000	<1.42
Enterococci	MPN/100 mL		>9,650	>24,200	#310	#243
Fecal Coliform	CFU/100 mL		>11,500,000	170,000	>19,000,000	#12,800
Classical Pollutants						
Alkalinity	mg/L		<38.4	ND(10.0)	34.4	58.2
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		2,570	52,300	155	85.5
Chemical Oxygen Demand (COD)	mg/L		1,440	26,800	127	154
Chloride (s)	mg/L		87.0	1,100	37.0	33.0
Hardness (e) (s)	mg/L		46.4	402	30.0	20.6
Hexane Extractable Material (HEM)	mg/L		215	688	35.2	17.0
Nitrate/Nitrite (NO2 + NO3-N) (s)	mg/L		<0.0296	0.120	0.123	0.0930
Settleable Residue	mL/L		56.4	1,000	<0.206	ND(0.118)
Silica Gel Treated HEM (SGT-HEM)	mg/L		<15.6	220	ND(5.80)	ND(4.60)
Sulfate	mg/L		16.6	41.2	29.1	28.2
Total Dissolved Solids (TDS) (s)	mg/L		712	6,710	137	194
Total Organic Carbon (TOC)	mg/L		386	1,560	39.0	43.9

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 for source water results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
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).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-5 (Continued)

Analyte	Unit	Priority Pollutant Code	Galley (SP-1)(a)	Food Pulper (SP-2)(a)	Accommodations (SP-3)(a)	Laundry (SP-4)(a)
Total Phosphorus	mg/L		41.6	308	2.74	7.56
Total Suspended Solids (TSS)	mg/L		1,550	29,400	58.8	30.2
Total and Dissolved Metals						
Aluminum, Total	ug/L		26,200	1,460	<117	147
Antimony, Total	ug/L	P114	ND(2.00)	7.05	ND(2.00)	ND(2.00)
Arsenic, Total	ug/L	P115	<2.24	18.7	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		26.2	66.5	9.56	30.5
Beryllium, Total	ug/L	P117	<0.286	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Total	ug/L		390	453	<50.9	<25.9
Cadmium, Total	ug/L	P118	<0.454	2.54	ND(0.0800)	<0.106
Calcium, Total (s)	ug/L		11,700	119,000	7,460	4,910
Chromium, Total	ug/L	P119	15.6	26.4	2.89	2.02
Cobalt, Total	ug/L		<0.798	2.34	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	408	312	167	495
Iron, Total (e) (s)	ug/L		1,380	1,570	412	134
Lead, Total (e)	ug/L	P122	<3.49	7.90	<2.58	<1.68
Magnesium, Total (s)	ug/L		4,160	25,400	2,770	2,030
Manganese, Total (e) (s)	ug/L		32.1	340	4.91	4.18
Mercury, Total	ug/L	P123	<0.132	0.680	<0.0556	<0.0560
Molybdenum, Total	ug/L		<1.72	11.2	ND(1.60)	ND(1.60)
Nickel, Total (e) (s)	ug/L	P124	16.8	27.9	8.37	3.11

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 for source water results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
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).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-5 (Continued)

Analyte	Unit	Priority Pollutant Code	Galley (SP-1)(a)	Food Pulper (SP-2)(a)	Accommodations (SP-3)(a)	Laundry (SP-4)(a)
Selenium, Total	ug/L	P125	<2.30	41.5	ND(1.40)	ND(1.40)
Silver, Total	ug/L	P126	<1.20	ND(0.770)	ND(0.770)	<0.790
Sodium, Total (s)	ug/L		81,400	EXCLUDE	20,500	35,400
Thallium, Total	ug/L	P127	ND(0.800)	1.48	<3.69	ND(2.24)
Tin, Total (e)	ug/L		17.3	113	<1.11	<1.34
Titanium, Total	ug/L		4.44	4.43	1.98	<0.650
Vanadium, Total	ug/L		<0.712	ND(0.470)	ND(0.470)	ND(0.470)
Yttrium, Total	ug/L		<0.328	ND(0.310)	ND(0.310)	ND(0.310)
Zinc, Total (e) (s)	ug/L	P128	500	987	323	455
Aluminum, Dissolved	ug/L		4,150	876	<46.9	<71.1
Antimony, Dissolved	ug/L	P114	ND(2.00)	7.79	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	14.9	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		5.61	71.7	7.56	32.0
Boron, Dissolved (e)	ug/L		453	586	<55.9	<34.6
Cadmium, Dissolved	ug/L	P118	<0.152	0.150	ND(0.0800)	<0.0920
Calcium, Dissolved (s)	ug/L		10,800	171,000	7,220	5,890
Chromium, Dissolved	ug/L	P119	1.73	5.37	1.21	1.16
Cobalt, Dissolved (s)	ug/L		5.25	29.5	<2.21	2.36
Copper, Dissolved (s)	ug/L	P120	61.8	23.9	89.1	553
Iron, Dissolved	ug/L		717	629	260	86.0
Lead, Dissolved	ug/L	P122	<1.23	ND(0.620)	<0.922	<1.17

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 for source water results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
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).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-5 (Continued)

Analyte	Unit	Priority Pollutant Code	Galley (SP-1)(a)	Food Pulper (SP-2)(a)	Accommodations (SP-3)(a)	Laundry (SP-4)(a)
Magnesium, Dissolved (s)	ug/L		4,190	29,300	3,060	2,520
Manganese, Dissolved (e) (s)	ug/L		17.4	46.2	7.21	6.58
Molybdenum, Dissolved	ug/L		ND(1.60)	6.01	ND(1.60)	ND(1.60)
Nickel, Dissolved (s)	ug/L	P124	9.97	28.2	8.11	2.94
Selenium, Dissolved	ug/L	P125	<1.42	27.0	ND(1.40)	ND(1.40)
Sodium, Dissolved (s)	ug/L		93,900	EXCLUDE	23,300	42,800
Tin, Dissolved	ug/L		<1.59	18.7	ND(0.940)	ND(0.940)
Vanadium, Dissolved	ug/L		ND(0.470)	0.660	ND(0.470)	ND(0.470)
Zinc, Dissolved (e)	ug/L	P128	324	634	218	464
Volatile and Semivolatile Organics						
Bis(2-ethylhexyl)phthalate	ug/L	P066	363	1,600	35.2	61.4
Bromodichloromethane	ug/L	P048	ND(5.00)	ND(10.0)	ND(5.00)	<5.00
Chloroform	ug/L	P023	<6.20	ND(10.0)	ND(5.00)	77.0
Diethyl Phthalate	ug/L	P070	<14.4	ND(50.0)	25.2	<12.4
Phenol (s)	ug/L	P065	49.4	100	<33.2	65.8
Toluene	ug/L	P086	13.8	ND(10.0)	ND(5.00)	ND(5.00)

(a) Sampling point location; see Figure 2-1.
(e) Analyte detected at some level in equipment blank. See Section 5.2.2 and Table 5-3 for equipment blank results.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 for source water results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
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).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-6

Influent to Treatment System Analytical Results, Norwegian Star

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-5)(a) Day 1	Influent to Treatment (SP-5)(a) Day 2	Influent to Treatment (SP-5)(a) Day 3	Influent to Treatment (SP-5)(a) Day 4	Influent to Treatment (SP-5)(a) Day 5	Average Influent to Treatment (SP-5)(a)
Pathogen Indicators								
E. coli (b)	MPN/100 mL		1,290,000[N=2]	2,880,000[N=2]	2,920,000[N=3]	9,610,000[N=3]	> 5,440,000[N=3]	>4,430,000
Enterococci (b)	MPN/100 mL		146,000[N=3]	443,000[N=2]	524,000[N=3]	243,000[N=3]	106,000[N=3]	292,000
Fecal Coliform (b)	CFU/100 mL		63,000,000[N=3]	93,000,000[N=2]	> 600,000,000[N=2]	41,000,000[N=2]	35,000,000[N=3]	>166,000,000
Classical Pollutants								
Alkalinity	mg/L		254	274	290	278	298	279
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		761	979	659	663	651	743
Chemical Oxygen Demand (COD)	mg/L		1,020	356	344	388	464	514
Chloride (s)	mg/L		85.0	145	75.0	75.0	95.0	95.0
Hardness (e) (s)	mg/L		47.7	56.0	42.8	47.9	54.8	49.8
Hexane Extractable Material (HEM)	mg/L		87.0	103	85.0	92.0	85.0	90.4
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.0330	0.0800	0.0490	0.0780	0.0490	0.0578
Settleable Residue	mL/L		39.0	24.0	23.0	21.0	31.0	27.6
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(4.00)	6.00	ND(5.00)	ND(5.00)	ND(5.00)	<5.00

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-5)(a) Day 1	Influent to Treatment (SP-5)(a) Day 2	Influent to Treatment (SP-5)(a) Day 3	Influent to Treatment (SP-5)(a) Day 4	Influent to Treatment (SP-5)(a) Day 5	Average Influent to Treatment (SP-5)(a)
Sulfate	mg/L		41.4	76.2	24.3	22.6	23.5	37.6
Total Dissolved Solids (TDS) (s)	mg/L		381	475	390	420	452	424
Total Organic Carbon (TOC)	mg/L		192	112	337	162	160	193
Total Phosphorus	mg/L		29.6	13.6	15.3	14.9	15.6	17.8
Total Suspended Solids (TSS)	mg/L		573	388	300	373	423	411
Total and Dissolved Metals								
Aluminum, Total	ug/L		6,860	2,310	3,730	2,220	2,590	3,540
Antimony, Total	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	2.37	<2.07
Barium, Total (e) (s)	ug/L		30.6	21.3	16.1	21.4	28.1	23.5
Beryllium, Total	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Total	ug/L		176	166	267	297	298	241
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	0.180	0.120	0.150	<0.122
Calcium, Total (s)	ug/L		12,700	10,200	9,950	12,000	14,700	11,900
Chromium, Total	ug/L	P119	8.62	9.99	4.86	4.22	4.92	6.52
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	423	395	300	290	304	342
Iron, Total (e) (s)	ug/L		1,080	752	610	697	735	775
Lead, Total (e)	ug/L	P122	3.92	2.25	2.19	ND(0.620)	ND(0.620)	<1.92
Magnesium, Total (s)	ug/L		3,890	7,420	4,350	4,380	4,380	4,880

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-5)(a) Day 1	Influent to Treatment (SP-5)(a) Day 2	Influent to Treatment (SP-5)(a) Day 3	Influent to Treatment (SP-5)(a) Day 4	Influent to Treatment (SP-5)(a) Day 5	Average Influent to Treatment (SP-5)(a)
Manganese, Total (e) (s)	ug/L		38.0	28.1	29.1	29.9	32.3	31.5
Mercury, Total	ug/L	P123	0.220	0.120	0.120	0.720	0.150	0.266
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (e) (s)	ug/L	P124	13.0	14.8	11.7	11.7	12.8	12.8
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Silver, Total	ug/L	P126	0.790	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	<0.774
Sodium, Total (s)	ug/L		53,300	86,800	60,500	64,500	66,300	66,300
Thallium, Total	ug/L	P127	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)
Tin, Total (e)	ug/L		14.3	7.95	9.17	11.1	12.4	11.0
Titanium, Total	ug/L		3.79	2.67	1.73	1.38	1.58	2.23
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Yttrium, Total	ug/L		ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)
Zinc, Total (e) (s)	ug/L	P128	450	359	300	312	322	349
Aluminum, Dissolved	ug/L		285	197	299	583	667	406
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		3.37	4.40	3.05	5.98	9.37	5.23
Boron, Dissolved (e)	ug/L		199	162	310	342	335	270
Cadmium, Dissolved	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Dissolved (s)	ug/L		6,470	6,190	7,070	9,190	10,400	7,860

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-5)(a) Day 1	Influent to Treatment (SP-5)(a) Day 2	Influent to Treatment (SP-5)(a) Day 3	Influent to Treatment (SP-5)(a) Day 4	Influent to Treatment (SP-5)(a) Day 5	Average Influent to Treatment (SP-5)(a)
Chromium, Dissolved	ug/L	P119	1.20	0.950	1.13	1.17	1.30	1.15
Cobalt, Dissolved (s)	ug/L		5.16	9.26	5.47	6.22	6.64	6.55
Copper, Dissolved (e) (s)	ug/L	P120	84.3	135	117	116	111	113
Iron, Dissolved	ug/L		363	333	286	402	398	356
Lead, Dissolved	ug/L	P122	ND(0.620)	ND(0.620)	ND(0.620)	1.26	1.33	<0.890
Magnesium, Dissolved (s)	ug/L		3,850	9,650	4,470	4,400	4,180	5,310
Manganese, Dissolved (e) (s)	ug/L		24.8	30.7	22.9	27.2	29.1	26.9
Molybdenum, Dissolved	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Dissolved (s)	ug/L	P124	9.12	10.2	11.0	10.6	10.7	10.3
Selenium, Dissolved	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Sodium, Dissolved (s)	ug/L		68,600	114,000	71,200	66,900	68,200	77,800
Tin, Dissolved	ug/L		2.01	1.71	2.81	ND(0.940)	ND(0.940)	<1.68
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (e)	ug/L	P128	61.0	91.6	98.8	116	132	99.9
Volatile and Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	120	89.0	88.0	93.0	130	104
Bromodichloromethane	ug/L	P048	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Chloroform	ug/L	P023	7.00	10.0	16.0	29.0	14.0	15.2
Diethyl Phthalate	ug/L	P070	ND(50.0)	16.0	11.0	14.0	11.0	<20.4
Phenol (s)	ug/L	P065	93.0	76.0	43.0	57.0	67.0	67.2

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-6 (Continued)

Analyte	Unit	Priority Pollutant Code	Influent to Treatment (SP-5)(a) Day 1	Influent to Treatment (SP-5)(a) Day 2	Influent to Treatment (SP-5)(a) Day 3	Influent to Treatment (SP-5)(a) Day 4	Influent to Treatment (SP-5)(a) Day 5	Average Influent to Treatment (SP-5)(a)
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Polychlorinated Biphenyls								
PCB-11			661 pg/L	NC	NC	NC	NC	
PCB-16			129 pg/L	NC	NC	NC	NC	
PCB-129+PCB-138+PCB-160+PCB-163			728 pg/L	NC	NC	NC	NC	
PCB-153+PCB-168			698 pg/L	NC	NC	NC	NC	
Total Dichloro Biphenyls			661 pg/L	NC	NC	NC	NC	
Total Hexachloro Biphenyls			1,430 pg/L	NC	NC	NC	NC	
Total PCBs			2,090 pg/L	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 three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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).
> - Average result includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-7

Influent to UV Disinfection Analytical Results, Norwegian Star

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 Disinfection (SP-6)(a) Day 1	Influent to UV Disinfection (SP-6)(a) Day 2	Influent to UV Disinfection (SP-6)(a) Day 3	Influent to UV Disinfection (SP-6)(a) Day 4	Influent to UV Disinfection (SP-6)(a) Day 5	Average Influent to UV Disinfection (SP-6)(a)
Pathogen Indicators							
E. coli (b)	MPN/100 mL	EXCLUDE	602[N=1]	2,330[N=3]	1,210[N=3]	7,050[N=3]	2,800
Enterococci (b)	MPN/100 mL	EXCLUDE	ND(10.0)[N=1]	ND(10.0)[N=3]	ND(10.0)[N=3]	ND(40.0)[N=3]	ND(17.5)
Fecal Coliform (b)	CFU/100 mL	168,000[N=2]	12,200[N=2]	> 330,000[N=2]	500[N=2]	< 1,000[N=3]	# 102,000

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=2]). See Appendix A-1 for all individual grab sample results.
EXCLUDE - Data excluded from the data set; see Section 5.1.
ND - Not detected (number in parentheses is detection limit).
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Includes at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).
- Average result includes at least one nondetect value (calculation uses detection limits for nondetected results) and at least one result flagged by the laboratory as ">" because the sample was not diluted sufficiently (see Appendix D).

Table 4-8

Effluent from Treatment System Analytical Results, Norwegian Star

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 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-7)(a) Day 1	Effluent from Treatment (SP-7)(a) Day 2	Effluent from Treatment (SP-7)(a) Day 3	Effluent from Treatment (SP-7)(a) Day 4	Effluent from Treatment (SP-7)(a) Day 5	Average Effluent from Treatment (SP-7)(a)
Pathogen Indicator								
E. coli (b)	MPN/100 mL		ND(1.00)[N=3]	ND(1.00)[N=3]	ND(1.00)[N=3]	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=3]	ND(1.00)[N=3]	ND(1.00)[N=3]	ND(1.00)
Fecal Coliform (b)	CFU/100 mL		< 4.67[N=3]	< 6.00[N=3]	ND(2.00)[N=2]	ND(2.00)[N=2]	ND(2.00)[N=3]	<3.33
Classical Pollutants								
Alkalinity	mg/L		57.0	60.0	63.0	64.0	65.0	61.8
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		7.79	4.92	11.6	4.37	6.11	6.96
Chemical Oxygen Demand (COD)	mg/L		40.0	34.0	41.0	24.5	28.0	33.5
Chloride (s)	mg/L		185	255	205	180	185	202
Hardness (e) (s)	mg/L		33.9	56.5	40.2	42.1	45.2	43.6
Hexane Extractable Material (HEM)	mg/L		ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		0.150	0.130	0.0845	0.478	< 0.0235	<0.173
Settleable Residue	mL/L		ND(0.115)	ND(0.110)	ND(0.100)	ND(0.100)	ND(0.100)	ND(0.105)
Silica Gel Treated HEM (SGT-HEM)	mg/L		ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Sulfate	mg/L		39.2	60.6	41.7	12.2	9.14	32.6
Total Dissolved Solids (TDS) (s)	mg/L		336	428	326	349	382	364
Total Organic Carbon (TOC)	mg/L		13.6	12.0	12.0	11.1	12.6	12.3

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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 4-8 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-7)(a) Day 1	Effluent from Treatment (SP-7)(a) Day 2	Effluent from Treatment (SP-7)(a) Day 3	Effluent from Treatment (SP-7)(a) Day 4	Effluent from Treatment (SP-7)(a) Day 5	Average Effluent from Treatment (SP-7)(a)
Total Phosphorus	mg/L		0.230	0.670	0.765	0.115	0.140	0.384
Total Suspended Solids (TSS)	mg/L		6.00	ND(5.00)	ND(5.00)	ND(5.00)	< 5.50	<5.30
Total and Dissolved Metals								
Aluminum, Total	ug/L		589	249	305	282	705	426
Antimony, Total	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Total	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Total (e) (s)	ug/L		4.28	5.79	4.77	4.97	9.07	5.77
Beryllium, Total	ug/L	P117	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)	ND(0.0700)
Boron, Total	ug/L		234	194	266	320	245	252
Cadmium, Total	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Total (s)	ug/L		8,350	9,110	8,610	10,000	11,600	9,540
Chromium, Total	ug/L	P119	0.580	ND(0.270)	ND(0.270)	ND(0.270)	ND(0.270)	<0.332
Cobalt, Total	ug/L		ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)	ND(0.660)
Copper, Total (e) (s)	ug/L	P120	11.3	8.16	11.4	8.25	8.30	9.48
Iron, Total (e) (s)	ug/L		393	305	315	296	338	329
Lead, Total (e)	ug/L	P122	1.84	< 1.05	1.41	ND(0.620)	ND(0.620)	<1.11
Magnesium, Total (s)	ug/L		3,160	8,200	4,540	4,130	3,920	4,790
Manganese, Total (e) (s)	ug/L		18.1	20.2	18.8	17.0	17.7	18.3
Mercury, Total	ug/L	P123	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)	ND(0.0500)
Molybdenum, Total	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Total (e) (s)	ug/L	P124	17.5	13.1	15.7	8.76	8.76	12.7
Selenium, Total	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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 4-8 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-7)(a) Day 1	Effluent from Treatment (SP-7)(a) Day 2	Effluent from Treatment (SP-7)(a) Day 3	Effluent from Treatment (SP-7)(a) Day 4	Effluent from Treatment (SP-7)(a) Day 5	Average Effluent from Treatment (SP-7)(a)
Silver, Total	ug/L	P126	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)	ND(0.770)
Sodium, Total (s)	ug/L		63,800	99,900	74,500	68,600	67,700	74,900
Thallium, Total	ug/L	P127	ND(0.800)	ND(0.800)	ND(0.800)	ND(0.800)	1.05	<0.850
Tin, Total (e)	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Titanium, Total	ug/L		ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Vanadium, Total	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Yttrium, Total	ug/L		ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)	ND(0.310)
Zinc, Total (e) (s)	ug/L	P128	576	747	805	638	597	673
Aluminum, Dissolved	ug/L		ND(8.80)	ND(8.80)	ND(8.80)	< 9.70	16.3	<10.5
Antimony, Dissolved	ug/L	P114	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Arsenic, Dissolved	ug/L	P115	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)	ND(2.00)
Barium, Dissolved (e) (s)	ug/L		3.95	4.99	4.11	4.94	8.55	5.31
Boron, Dissolved (e)	ug/L		242	148	282	359	264	259
Cadmium, Dissolved	ug/L	P118	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)	ND(0.0800)
Calcium, Dissolved (s)	ug/L		8,710	8,560	8,110	9,940	11,400	9,340
Chromium, Dissolved	ug/L	P119	0.790	ND(0.270)	ND(0.270)	ND(0.270)	ND(0.270)	<0.374
Cobalt, Dissolved (s)	ug/L		2.08	< 1.55	ND(0.660)	< 1.53	1.83	<1.53
Copper, Dissolved (s)	ug/L	P120	6.03	5.48	11.3	5.45	4.31	6.51
Iron, Dissolved	ug/L		43.3	ND(9.80)	34.0	26.8	47.0	<32.2
Lead, Dissolved	ug/L	P122	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)	ND(0.620)
Magnesium, Dissolved (s)	ug/L		3,340	7,900	4,660	4,140	3,940	4,800
Manganese, Dissolved (e) (s)	ug/L		21.3	20.6	19.9	18.6	20.5	20.2

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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 4-8 (Continued)

Analyte	Unit	Priority Pollutant Code	Effluent from Treatment (SP-7)(a) Day 1	Effluent from Treatment (SP-7)(a) Day 2	Effluent from Treatment (SP-7)(a) Day 3	Effluent from Treatment (SP-7)(a) Day 4	Effluent from Treatment (SP-7)(a) Day 5	Average Effluent from Treatment (SP-7)(a)
Molybdenum, Dissolved	ug/L		ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)	ND(1.60)
Nickel, Dissolved (s)	ug/L	P124	17.4	11.7	17.5	8.52	8.73	12.8
Selenium, Dissolved	ug/L	P125	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)	ND(1.40)
Sodium, Dissolved (s)	ug/L		65,900	93,100	65,500	61,900	63,200	69,900
Tin, Dissolved	ug/L		ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)	ND(0.940)
Vanadium, Dissolved	ug/L		ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)	ND(0.470)
Zinc, Dissolved (e)	ug/L	P128	553	649	883	614	581	656
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)
Bromodichloromethane	ug/L	P048	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Chloroform	ug/L	P023	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)
Diethyl Phthalate	ug/L	P070	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)	ND(10.0)
Phenol (s)	ug/L	P065	61.5	47.0	67.0	42.0	33.0	50.1
Toluene	ug/L	P086	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)	ND(5.00)

(a) Sampling point location; see Figure 2-2.
(b) Samples for pathogen indicator analyses were collected as grab samples for individual analysis, with three grab samples collected per 24-hour sampling period (some pathogen indicator results were excluded, see Section 5.1). 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=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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 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 4-9

Wastewater Treatment System: Performance Data for Pathogen Indicators, Norwegian Star

Pathogen indicators performance data for Star's Scanship wastewater treatment system. Average analyte concentrations were determined from the daily results presented in Tables 4-6 through 4-8. Percent removals were calculated using the average influent to and effluent from treatment analyte concentrations.

Analyte	Unit	Average Influent to Treatment Concentration (SP-5)(a)	Average Influent to UV Disinfection Concentration (SP-6)(a)	Average Effluent from Treatment Concentration (SP-7)(a)	Percent Removal
Pathogen Indicators					
E. coli	MPN/100 mL	> 4,430,000	2,800	ND(1.00)	> 99
Enterococci	MPN/100 mL	292,000	ND(17.5)	ND(1.00)	> 99
Fecal Coliform	CFU/100 mL	> 166,000,000	# 102,000	< 3.33	> 99

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

Table 4-10

Wastewater Treatment System: Performance Data for Analytes Other Than Pathogen Indicators, Norwegian Star

Performance data for the Star's Scanship 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 4-6 and 4-8. 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-5)(a)	Influent to Treatment Concentration Range (SP-5)(a)	Average Effluent from Treatment Concentration (SP-7)(a)	Effluent from Treatment Concentration Range (SP-7)(a)	Percent Removal
Classical Pollutants							
Alkalinity	mg/L		279	254 - 298	61.8	57.0 - 65.0	78
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		743	651 - 979	6.96	4.37 - 11.6	99
Chemical Oxygen Demand (COD)	mg/L		514	344 - 1,020	33.5	24.5 - 41.0	93
Chloride (s)	mg/L		95.0	75.0 - 145	202	180 - 255	NC
Hardness (e) (s)	mg/L		49.8	42.8 - 56.0	43.6	33.9 - 56.5	13
Hexane Extractable Material (HEM)	mg/L		90.4	85.0 - 103	ND(5.00)	ND(5.00)	> 94
Nitrate/Nitrite (NO2-N+ NO3-N) (s)	mg/L		0.0578	0.0330 - 0.0800	<0.173	<0.0235 - 0.478	NC
Settleable Residue	mL/L		27.6	21.0 - 39.0	ND(0.105)	ND(0.100) - ND(0.115)	> 99
Silica Gel Treated HEM (SGT-HEM)	mg/L		<5.00	ND(4.00) - 6.00	ND(5.00)	ND(5.00)	> 0.0
Sulfate	mg/L		37.6	22.6 - 76.2	32.6	9.14 - 60.6	13
Total Dissolved Solids (TDS) (s)	mg/L		424	381 - 475	364	326 - 428	14
Total Organic Carbon (TOC)	mg/L		193	112 - 337	12.3	11.1 - 13.6	94

(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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
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.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-10 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Treatment Concentration (SP-5)(a)	Influent to Treatment Concentration Range (SP-5)(a)	Average Effluent from Treatment Concentration (SP-7)(a)	Effluent from Treatment Concentration Range (SP-7)(a)	Percent Removal
Total Phosphorus	mg/L		17.8	13.6 - 29.6	0.384	0.115 - 0.765	98
Total Suspended Solids (TSS)	mg/L		411	300 - 573	<5.30	ND(5.00) - 6.00	99
Total and Dissolved Metals							
Aluminum, Total	ug/L		3,540	2,220 - 6,860	426	249 - 705	88
Arsenic, Total	ug/L	P115	<2.07	ND(2.00) - 2.37	ND(2.00)	ND(2.00)	> 3.6
Barium, Total (e) (s)	ug/L		23.5	16.1 - 30.6	5.77	4.28 - 9.07	75
Boron, Total	ug/L		241	166 - 298	252	194 - 320	NC
Cadmium, Total	ug/L	P118	<0.122	ND(0.0800) - 0.180	ND(0.0800)	ND(0.0800)	> 34
Calcium, Total (s)	ug/L		11,900	9,950 - 14,700	9,540	8,350 - 11,600	20
Chromium, Total	ug/L	P119	6.52	4.22 - 9.99	<0.332	ND(0.270) - 0.580	95
Copper, Total (e) (s)	ug/L	P120	342	290 - 423	9.48	8.16 - 11.4	97
Iron, Total (e) (s)	ug/L		775	610 - 1,080	329	296 - 393	57
Lead, Total (e)	ug/L	P122	<1.92	ND(0.620) - 3.92	<1.11	ND(0.620) - 1.84	42
Magnesium, Total (s)	ug/L		4,880	3,890 - 7,420	4,790	3,160 - 8,200	2.0
Manganese, Total (e) (s)	ug/L		31.5	28.1 - 38.0	18.3	17.0 - 20.2	42
Mercury, Total	ug/L	P123	0.266	0.120 - 0.720	ND(0.0500)	ND(0.0500)	> 81
Nickel, Total (e) (s)	ug/L	P124	12.8	11.7 - 14.8	12.7	8.76 - 17.5	0.45
Silver, Total	ug/L	P126	<0.774	ND(0.770) - 0.790	ND(0.770)	ND(0.770)	> 0.52
Sodium, Total (s)	ug/L		66,300	53,300 - 86,800	74,900	63,800 - 99,900	NC
Thallium, Total	ug/L	P127	ND(0.800)	ND(0.800)	<0.850	ND(0.800) - 1.05	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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
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.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-10 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Treatment Concentration (SP-5)(a)	Influent to Treatment Concentration Range (SP-5)(a)	Average Effluent from Treatment Concentration (SP-7)(a)	Effluent from Treatment Concentration Range (SP-7)(a)	Percent Removal
Tin, Total (e)	ug/L		11.0	7.95 - 14.3	ND(0.940)	ND(0.940)	> 91
Titanium	ug/L		2.23	1.38 - 3.79	ND(0.620)	ND(0.620)	> 72
Zinc, Total (e) (s)	ug/L	P128	349	300 - 450	673	576 - 805	NC
Aluminum, Dissolved	ug/L		406	197 - 667	<10.5	ND(8.80) - 16.3	97
Barium, Dissolved (e) (s)	ug/L		5.23	3.05 - 9.37	5.31	3.95 - 8.55	NC
Boron, Dissolved (e)	ug/L		270	162 - 342	259	148 - 359	3.9
Calcium, Dissolved (s)	ug/L		7,860	6,190 - 10,400	9,340	8,110 - 11,400	NC
Chromium, Dissolved	ug/L	P119	1.15	0.950 - 1.30	<0.374	ND(0.270) - 0.790	67
Cobalt, Dissolved (s)	ug/L		6.55	5.16 - 9.26	<1.53	ND(0.660) - 2.08	77
Copper, Dissolved (s)	ug/L	P120	113	84.3 - 135	6.51	4.31 - 11.3	94
Iron, Dissolved	ug/L		356	286 - 402	<32.2	ND(9.80) - 47.0	91
Lead, Dissolved	ug/L	P122	<0.890	ND(0.620) - 1.33	ND(0.620)	ND(0.620)	> 30
Magnesium, Dissolved (s)	ug/L		5,310	3,850 - 9,650	4,800	3,340 - 7,900	9.7
Manganese, Dissolved (e) (s)	ug/L		26.9	22.9 - 30.7	20.2	18.6 - 21.3	25
Nickel, Dissolved (s)	ug/L	P124	10.3	9.12 - 11.0	12.8	8.52 - 17.5	NC
Sodium, Dissolved (s)	ug/L		77,800	66,900 - 114,000	69,900	61,900 - 93,100	10
Tin, Dissolved	ug/L		<1.68	ND(0.940) - 2.81	ND(0.940)	ND(0.940)	> 44
Zinc, Dissolved (e)	ug/L	P128	99.9	61.0 - 132	656	553 - 883	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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
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.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-10 (Continued)

Analyte	Unit	Priority Pollutant Code	Average Influent to Treatment Concentration (SP-5)(a)	Influent to Treatment Concentration Range (SP-5)(a)	Average Effluent from Treatment Concentration (SP-7)(a)	Effluent from Treatment Concentration Range (SP-7)(a)	Percent Removal
Volatile and Semivolatile Organics							
Bis(2-ethylhexyl)phthalate	ug/L	P066	104	88.0 - 130	ND(10.0)	ND(10.0)	> 90
Chloroform	ug/L	P023	15.2	7.00 - 29.0	ND(5.00)	ND(5.00)	> 67
Diethyl Phthalate	ug/L	P070	<20.4	ND(50.0) - 16.0	ND(10.0)	ND(10.0)	> 51
Phenol (s)	ug/L	P065	67.2	43.0 - 93.0	50.1	33.0 - 67.0	25

(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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
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.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).
> - Indicates a minimum level of removal.

Table 4-11

Treatment System Residual and Incinerator Ash Analytical Results, Norwegian Star

Analytical results for one-time grab samples of treatment system residual (coarse drum filter solids 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). Figure 2-3 identifies 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 4-6) for comparison. Priority pollutants (designated by EPA in 40 CFR Part 423, Appendix A) are identified where applicable.

Analyte	Priority Pollutant Code	Dried Wastewater Treatment Sludge (SP-9)(a) Day 1	Incinerator Ash (SP-9)(a) Day 4	Average Influent to Treatment (SP-5)(a)
Classical Pollutants				
Alkalinity		24,200 mg/kg	NC	279 mg/L
Chemical Oxygen Demand (COD)		326,000 mg/kg	NC	514 mg/L
Chloride (s)		3,890 mg/kg	NC	95.0 mg/L
Nitrate/Nitrite (NO2-N + NO3-N) (s)		8.65 mg/kg	NC	0.0578 mg/L
Sulfate		1,020 mg/kg	NC	37.6 mg/L
Total Organic Carbon (TOC)		62,100 mg/kg	NC	193 mg/L
Total Phosphorus		436 mg/kg	NC	17.8 mg/L
Total Metals				
Aluminum, Total		45,200 mg/kg	60,900 mg/kg	3,540 ug/L
Antimony, Total	P114	ND(0.370) mg/kg	26.4 mg/kg	ND(2.00) ug/L
Arsenic, Total	P115	ND(0.370) mg/kg	ND(0.600) mg/kg	<2.07 ug/L
Barium, Total (s)		30.2 mg/kg	712 mg/kg	23.5 ug/L
Beryllium, Total	P117	0.370 mg/kg	0.440 mg/kg	ND(0.0700) ug/L
Boron, Total		5.49 mg/kg	287 mg/kg	241 ug/L

(a) Sampling point location; see Figure 2-3.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 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).

Table 4-11 (Continued)

Analyte	Priority Pollutant Code	Dried Wastewater Treatment Sludge (SP-9)(a) Day 1	Incinerator Ash (SP-9)(a) Day 4	Average Influent to Treatment (SP-5)(a)
Cadmium, Total	P118	ND(0.0400) mg/kg	0.640 mg/kg	<0.122 ug/L
Calcium, Total (s)		4.990 mg/kg	328,000 mg/kg	11,900 ug/L
Chromium, Total	P119	11.7 mg/kg	222 mg/kg	6.52 ug/L
Cobalt, Total		0.480 mg/kg	17.6 mg/kg	ND(0.660) ug/L
Copper, Total (e) (s)	P120	406 mg/kg	778 mg/kg	342 ug/L
Iron, Total (e) (s)		907 mg/kg	10,100 mg/kg	775 ug/L
Lead, Total (e)	P122	2.59 mg/kg	69.3 mg/kg	<1.92 ug/L
Magnesium, Total (s)		1,180 mg/kg	14,100 mg/kg	4,880 ug/L
Manganese, Total (e) (s)		22.7 mg/kg	437 mg/kg	31.5 ug/L
Mercury, Total	P123	0.300 mg/kg	ND(0.0200) mg/kg	0.266 ug/L
Molybdenum, Total		1.67 mg/kg	18.9 mg/kg	ND(1.60) ug/L
Nickel, Total (e) (s)	P124	9.51 mg/kg	81.0 mg/kg	12.8 ug/L
Selenium, Total	P125	1.50 mg/kg	ND(0.460) mg/kg	ND(1.40) ug/L
Silver, Total	P126	0.550 mg/kg	10.3 mg/kg	<0.774 ug/L
Sodium, Total (s)		775 mg/kg	19,100 mg/kg	66,300 ug/L
Tin, Total (e)		18.7 mg/kg	198 mg/kg	11.0 ug/L
Titanium, Total		8.97 mg/kg	2,950 mg/kg	2.23 ug/L
Vanadium, Total		1.00 mg/kg	33.7 mg/kg	ND(0.470) ug/L
Yttrium, Total		0.160 mg/kg	2.93 mg/kg	ND(0.310) ug/L
Zinc, Total (e) (s)	P128	339 mg/kg	2,770 mg/kg	349 ug/L

(a) Sampling point location; see Figure 2-3.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 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).

Table 4-11 (Continued)

Analyte	Priority Pollutant Code	Dried Wastewater Treatment Sludge (SP-9)(a) Day 1	Incinerator Ash (SP-9)(a) Day 4	Average Influent to Treatment (SP-5)(a)
Volatile and Semivolatile Organics				
Bis(2-ethylhexyl)phthalate	P066	130,000 mg/kg	400 ug/kg	104 ug/L
Chloroform	P023	ND(6.00) mg/kg	NC	15.2 ug/L
Diethyl Phthalate	P070	ND(40,000) mg/kg	ND(300) ug/kg	<20.4 ug/L
Ethylbenzene	P038	40.0 mg/kg	NC	ND(5.00) ug/L
Phenol (s)	P065	ND(40,000) mg/kg	ND(300) ug/kg	67.2 ug/L
Toluene	P086	25.0 mg/kg	NC	ND(5.00) ug/L
Dioxins and Furans				
1,2,3,4,6,7,8-HpCDD		NC	7.69 pg/g	NC
1,2,3,4,6,7,8-HpCDF		NC	12.1 pg/g	NC
1,2,3,4,7,8-HxCDF		NC	8.51 pg/g	NC
2,3,4,6,7,8-HxCDF		NC	4.51 pg/g	NC
2,3,4,7,8-PeCDF		NC	5.16 pg/g	NC
2,3,7,8-TCDF		NC	3.97 pg/g	NC
Octachlorodibenzo-p-dioxin		NC	13.5 pg/g	NC

(a) Sampling point location; see Figure 2-3.
(s) Analyte detected at some level in source water. See Section 4.1.7 and Table 4-12 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).

Table 4-12

Source Water Analytical Results, Norwegian Star

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-11)(a) Day 4	Federal Drinking Water Standards (b)
Classical Pollutants				
Biochemical Oxygen Demand (BOD_5)	mg/L		15.2	
Chloride	mg/L		25.0	250
Hardness	mg/L		23.9	
Nitrate/Nitrite (NO2-N + NO3-N)	mg/L		0.0130	10 (Nitrate) 1 (Nitrite)
Total Dissolved Solids (TDS)	mg/L		66.0	500
Total and Dissolved Metals				
Barium, Total	ug/L		1.04	2,000
Calcium, Total	ug/L		4,830	
Copper, Total	ug/L	P120	403	1,300
Iron, Total	ug/L		45.2	300
Magnesium, Total	ug/L		2,880	
Manganese, Total	ug/L		1.89	50
Nickel, Total	ug/L	P124	3.81	
Sodium, Total	ug/L		7,470	
Zinc, Total	ug/L	P128	23.8	5,000
Barium, Dissolved	ug/L		0.950	
Calcium, Dissolved	ug/L		4,290	
Cobalt, Dissolved	ug/L		1.28	
Copper, Dissolved	ug/L	P120	288	
Magnesium, Dissolved	ug/L		2,690	
Manganese, Dissolved	ug/L		1.78	
Nickel, Dissolved	ug/L	P124	3.76	
Sodium, Dissolved	ug/L		6,480	
Volatile and Semivolatile Organics				
Phenol	ug/L	P065	69.0	

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

Table 4-13

Galley Cleaning Agents Used Onboard Norwegian Star

Chemical Name	Ingredients According to Material Safety Data Sheets
Dip It XP (powered high alkaline oxygenated cleaner)	20% sodium phosphate, tribasic 20-50% sodium metasilicate 25% sodium perborate 5-20% sodium carbonate (soda ash) 5-20% chelating agent 1-5% nonionic surfactant
Solid Power (solid high caustic warewash detergent)	41% sodium hydroxide (caustic soda) 5-20% sodium carbonate (soda ash) 27% sodium phosphate, tribasic
Super Trump (liquid alkaline automatic dishmachine detergent)	24% sodium hydroxide
Balanced Fusion (solid chlorinated warewashing detergent)	1% sodium dichloroisocyanurate dihydrate 29% sodium tripolyphosphate 42% sodium carbonate (soda ash) 3% sodium silicate 4% surfactants
Greasecutter Plus (liquid alkaline oven cleaner/degreaser)	5% sodium hydroxide (caustic soda) 1-5% ethanolamine (MEA) 1-5% anionic surfactant
Lime-A-Way (liquid high acid cleaner/delimer)	32% phosphoric acid 1-5% nonionic surfactant
Scout (liquid manual pot and pan detergent)	12% sodium linear alkylbenzenesulfonate 12% triethanolamine alkylbenzenesulfonate 5-20% anionic and nonionic surfactants
Oasis (all purpose cleaner concentrate)	5-20% nonionic and anionic surfactants 1-5% quaternary ammonium chloride compound
Bleach	5.4-5.9% sodium hypochlorite
Clean and Smooth (liquid lotion hand cleaner)	Ingredients not listed in MSDS.
Gamazyme (biological cleaner)	Specialized bacteria

Table 4-14

Flow Data by Sampling Period, Norwegian Star

Flow data collected via strap-on ultrasonic flow meters installed by the sampling team. Figures 2-1 and 2-2 show the flow meter locations. Flow per capita was calculated by dividing the daily flow totals by the number of passengers and crew (3,735 people) onboard the Star during the sampling episode.

Sampling Period	Total Daily Flow (m^3)									
	Galley (SP-1)(a)		Accommodations (SP-3)(a)		Laundry (SP-4)(a)		Influent to Treatment System (SP-5)(a)		Effluent from Treatment System (SP-7)(a)	
	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita, gallons/day/person (m^3/day/person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita, gallons/day/person (m^3/day/person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita gallons/day/person (m^3/day/person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita, gallons/day/person (m^3/day/person)	Daily Total Flow, gallons/day (m^3/day)	Daily Flow Per Capita, gallons/day/person (m^3/day/person)
Day 1	128,000 (485)	34.2 (0.130)	10,100 (38.1)	NC	46,700 (177)	12.4 (0.047)	227,000 (859)	79.2 (0.300)	225,000 (853)	60.2 (0.228)
Day 2	66,500 (252)	17.7 (0.067)	10,700 (40.7)	NC	40,400 (153)	10.8 (0.041)	211,000 (799)	56.5 (0.214)	216,000 (817)	57.8 (0.219)
Day 3	66,800 (253)	18.0 (0.068)	10,200 (38.8)	NC	45,900 (174)	12.4 (0.047)	237,000 (896)	63.4 (0.240)	235,000 (891)	63.1 (0.239)
Day 4	95,600 (362)	25.6 (0.097)	9,670 (36.7)	NC	50,000 (189)	13.5 (0.051)	189,000 (716)	50.7 (0.192)	192,000 (729)	51.5 (0.195)
Day 5	53,600 (203)	14.3 (0.054)	10,300 (39.0)	NC	42,800 (162)	11.4 (0.043)	238,000 (902)	63.6 (0.241)	240,000 (910)	64.4 (0.244)
Average	80,800 (306)	21.6 (0.082)	10,200 (38.7)	NC	45,100 (171)	12.1 (0.046)	220,000 (834)	58.9 (0.223)	222,000 (840)	59.4 (0.225)

(a) Sampling point location; see Figures 2-1 and 2-2.
NC - Not calculated because accommodations wastewater flows were measured for only 1 of 14 accommodations wastewater collection tanks.

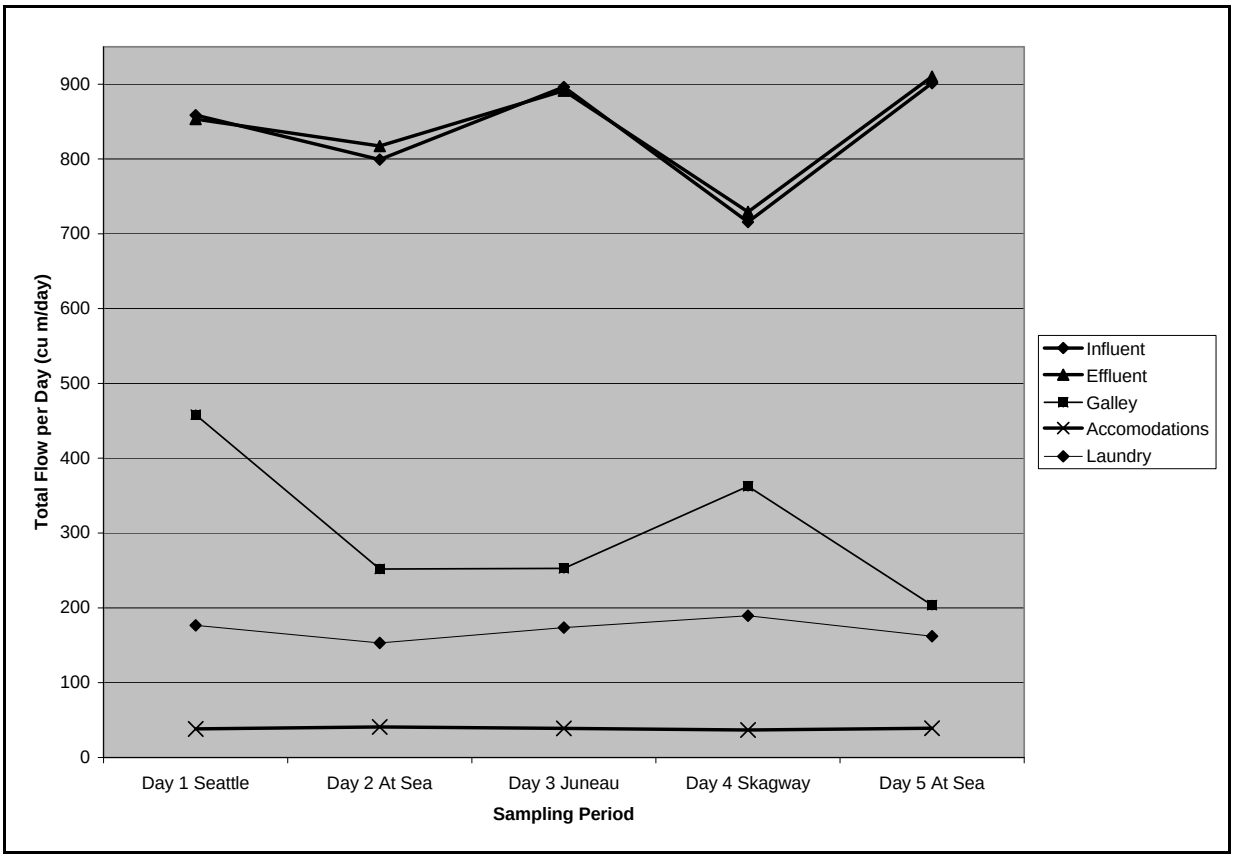

Figure 4-1. Total Daily Flow, Norwegian Star

Flow data collected via strap-on ultrasonic flow meters installed by the sampling team. Flow are presented as daily totals for each location. Figures 2-1 and 2-2 show the flow meter locations.

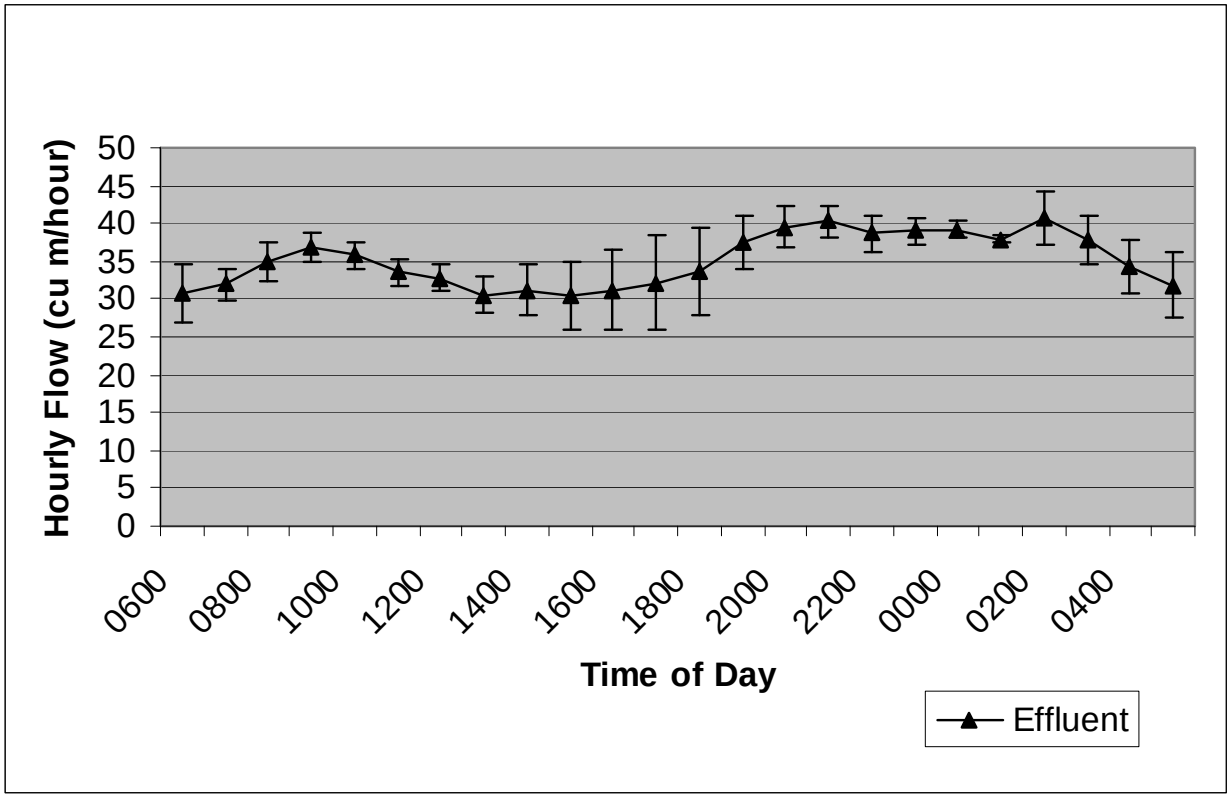

Figure 4-2. Average Hourly Wastewater Treatment System Flow, Norwegian Star

Average effluent flow for each hour interval over the five consecutive 24-hour sampling periods, calculated and plotted from the strap-on flow meters installed by the sampling team. Figure 2-2 shows the flow meter location. Bars represent the standard error of the hourly flow calculated for the five consecutive sampling days. Standard error is calculated as the standard deviation divided by the square root of the number of hourly flow measurements (five).

5.0 DATA QUALITY

Quality assurance/quality control (QA/QC) procedures applicable to the Star sampling episode are outlined in the *Quality Assurance Project Plan for Rulemaking Support for Large Cruise Ships in Alaska Waters (QAPP)*, which can be found 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 conducting quality control 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:

- Fifteen fecal coliform results in samples 65395, 65400, 65403, 65424, 65427, 65444, 65447, 65465, 65467, 65467, 65479, 65485, 65487, 65505, and 65507.
- Six *E. coli* results in samples 65456, 65475, 65476, 65477, 65479, and 65480;
- Five enterococci results in samples 65475, 65476, 65477, 65479, and 65480;

- One dissolved and total sodium result in sample 65411;
- One sulfate result in sample 65547;
- Two organo-phosphorus pesticide results (methamidophos in samples 65395 and 65459); and
- One available cyanide result in sample 65539.

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. 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 (see memoranda *Data Review Narrative for Classical Analyses for the Alaska Cruise Ship Industry Episode 6504* and *Issues Associated with Results for Total Cyanide Versus Available Cyanide* in Appendix D for a complete discussion).

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

5.1.2 Ammonia Results

EPA considers the Star ammonia data (and associated total Kjeldahl nitrogen (TKN) data of which ammonia is a component) to be anomalous because ammonia was not detected in any of the influent to or effluent from treatment system samples. Although these data have not been excluded from the database, the results are presented in Table 5-2 and not in the analytical results summary tables in Section 4.1.

Ammonia is produced within humans when proteins are digested and used by the body, and excess ammonia is excreted in urine. Therefore, ammonia is expected to be present in combined cruise vessel graywater and sewage. In general, 2004 compliance testing data provided by the U.S. Coast Guard (a total of 25 data points) for treated cruise ship wastewater showed ammonia concentrations generally ranging from 4 mg/L to 110 mg/L, with an average concentration 31 mg/L. None of these ammonia concentrations were reported as non-detect.

Furthermore, one of the Alaska Department of Environmental Conservation (ADEC) compliance testing samples was collected during EPA's Star sampling episode. Although the sampling methodology differed (24-hour composite sample for EPA's sample versus grab sample for the compliance sample), the sampling location and analytical test method were the same. EPA's effluent sampling result for ammonia was non-detect (detection limit = 0.05 mg/L), while the compliance sampling result for ammonia was 68 mg/L.

In addition, the TKN results for the Star were unexpectedly low and variable as compared to results from other cruise ships. TKN concentrations in the influent to and effluent from treatment samples collected over five consecutive days, ordered from lowest to highest concentration, for the four sampled ships are shown below.

Ship	TKN Concentrations (mg/L)	
	Influent to Treatment	**Effluent from Treatment**
Holland America Veendam	60.0, 63.0, 68.0, 80.0, 84.0	11.0, 12.0, 12.0, 28.0, 29.0
Norwegian Star	0.310, 0.760, 3.87, 6.03, 83.7	0.155, 0.760, 0.780, 10.3, 46.3
Island Princess	69.6, 80.2, 84.6, 97.6, 139	27.9, 38.1, 41.1, 42.6, 47.3
Holland America Oosterdam (Graywater/Sewage Treatment System)	182, 192, 192, 197, 200	4.13, 64.0, 68.6, 72.4, 83.2

With the exception of the Star and the Oosterdam, TKN concentrations fall in a relatively narrow range (generally within the same order of magnitude).

In addition, as discussed previously, ADEC compliance testing was conducted during EPA's sampling episode onboard the Star. EPA's effluent sampling result for TKN was

46.3 mg/L, while the compliance sampling result for TKN was 60.3 mg/L. While these results are similar, EPA's result is lower than the ADEC's TKN result.

It is important to note that EPA's review of the ammonia and TKN analytical data for all four sampling episodes did not reveal any obvious errors. The quality control results from each laboratory support the results provided and do not suggest any pervasive problems with the analyses (i.e., matrix spike recoveries and ongoing precision and recovery results were well within the acceptance limits, blanks were free of ammonia at the levels of interest). The Veendam and the Island ammonia and TKN samples were analyzed by a different laboratory than the Star and the Oosterdam ammonia and TKN samples.

EPA considers ammonia and TKN to be critical analytes in characterizing graywater and sewage generation and treatment onboard cruise vessels. Accordingly, EPA believed it was necessary to collect additional ammonia and TKN data to better assess these analytes in cruise ship wastewater. During the 2005 cruise season, EPA conducted a supplementary sampling program to collect samples of the influents to and effluents from the treatment systems onboard the same four ships that were sampled in 2004. Five sets of samples were collected from each ship and analyzed for nitrogen compounds (ammonia, TKN, and nitrate/nitrite). Samples were also analyzed for chemical oxygen demand and total suspended solids to benchmark these classical pollutant concentrations to those measured during the 2004 cruise season. The 2005 sampling activities, including the analytical results, will be described in a separate sampling episode report.

5.1.3 Biochemical and Chemical Oxygen Demand Results

Biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) are test methods used to measure the content of organic matter in wastewater by determining the amount of oxygen consumed during decomposition of the organic matter. The BOD_5 test method decomposes organic matter using microorganisms, while the COD test method decomposes organic matter using a strong chemical agent in an acidic medium at an elevated temperature. In general, the COD concentration in any given sample should be greater than the BOD_5 concentration for that same sample because more compounds can be chemically oxidized than can

be biologically oxidized. For many wastes, it is possible to develop a correlation between COD and BOD_5.

For the Star sampling episode, BOD_5 concentrations exceeded COD concentrations in galley, food pulper, accommodations, and influent to treatment system samples. Norwegian Cruise Line identified these results as anomalous, indicating that influent to treatment COD concentrations are typically 2 to 2.5 times greater than BOD_5 concentrations and as high as 15 times greater than BOD_5 concentrations.

EPA's review of the BOD_5 and COD data did not reveal any obvious errors. The quality control results from each laboratory support the results provided and do not suggest any pervasive problems with the analyses. Accordingly, there is no way to determine either the reason for these anomalous results or which analysis is correct. EPA has not excluded the BOD_5 and COD results from either the database or the analytical results summary tables in Section 4.1; however, data users should consider limitations of sample results.

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 Star 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 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 August 13, 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 5-3 presents the detected results for the equipment blank. Eight total metals and four dissolved metals were detected in the equipment blank. Table 5-3 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 12 of these metals analytes hardness are flagged with an "(e)" to indicate they were detected in the equipment blank. EPA will consider the impact of possible contamination from 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, Total and Dissolved Metals, and Semivolatile Organics

For classical pollutants, 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-7/8). Note that duplicate samples for dioxins and furans and pesticide analytes were collected during a previous sampling episode, and duplicate samples for HEM/SGT-HEM were not planned for this sampling program.

Table 5-4 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.

There was excellent precision in sampling and analysis for this sampling episode. Of the180 duplicate pairs listed in Table 5-4, 165 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 7 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 eight duplicate pairs with an RPD outside of the target (i.e., $\geq$30% difference) include one of three duplicate pairs for each of chemical oxygen demand, nitrate/nitrite, total Kjeldahl nitrogen, total aluminum, total boron, total chromium, total iron, and phenol. 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 and Volatile Organics

For pathogen indicators and volatile organics, 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-7/8). Table 5-5 presents analytical results and the RPDs for these duplicate samples. RPDs could not be calculated for any of the 33 duplicate sample pairs listed in Table 5-5 because both of the duplicate samples were less than the detection limit.

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, Norwegian Star

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

Waste Stream	Available Cyanide (ug/L)	Total Cyanide (mg/L)
Galley (SP-1), Day 1	5.64	ND(0.00500)
Galley (SP-1), Day 2	22.4	ND(0.00500)
Galley (SP-1), Day 3	ND(2.00)	ND(0.00500)
Galley (SP-1), Day 4	ND(2.00)	ND(0.00500)
Galley (SP-1), Day 5	2.03	ND(0.00500)
Food Pulper (SP-2)	35.7	0.00600
Accommodations (SP-3), Day 1	ND(2.00)	ND(0.00500)
Accommodations (SP-3), Day 2	ND(2.00)	ND(0.00500)
Accommodations (SP-3), Day 3	ND(2.00)	ND(0.00500)
Accommodations (SP-3), Day 4	ND(2.00)	ND(0.00500)
Accommodations (SP-3), Day 5	ND(2.00)	ND(0.00500)
Laundry (SP-4), Day 1	ND(2.00)	ND(0.00500)
Laundry (SP-4), Day 2	ND(2.00)	ND(0.00500)
Laundry (SP-4), Day 3	ND(2.00)	ND(0.00500)
Laundry (SP-4), Day 4	ND(2.00)	ND(0.00500)
Laundry (SP-4), Day 5	2.39	ND(0.00500)
Influent to Treatment (SP-5), Day 1	26.9	ND(0.00500)
Influent to Treatment (SP-5), Day 2	29.0	ND(0.00500)
Influent to Treatment (SP-5), Day 3	11.7	ND(0.00500)
Influent to Treatment (SP-5), Day 4	11.5	ND(0.00500)
Influent to Treatment (SP-5), Day 5	11.6	ND(0.00500)
Effluent from Treatment (SP-7), Day 1	ND(2.00)	ND(0.00500)
Effluent from Treatment (SP-7), Day 2	ND(2.00)	ND(0.00500)
Effluent from Treatment (SP-7), Day 3	ND(2.00)	< 0.00800
Effluent from Treatment (SP-7), Day 4	ND(2.00)	ND(0.00500)
Effluent from Treatment (SP-7), Day 5	ND(2.00)	ND(0.00500)
Dried Wastewater Treatment Sludge (SP-9), Day 1	NC	EXCLUDE
Source Water (SP-11), Day 4	ND(2.00)	ND(0.00500)

EXCLUDE - Data excluded from the data set (see data review narratives in Appendix D for details).
NC - Not collected.
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 5-2

Ammonia as Nitrogen and Total Kjeldahl Nitrogen Analytical Results, Norwegian Star

Ammonia and total Kjeldahl nitrogen analytical results are anomalous; see Section 5.1.2.

Waste Stream	Ammonia As Nitrogen (NH3-N)	Total Kjeldahl Nitrogen (TKN)
Galley (SP-1), Day 1	0.210 mg/L	9.60 mg/L
Galley (SP-1), Day 2	ND(0.0500) mg/L	37.2 mg/L
Galley (SP-1), Day 3	ND(0.0500) mg/L	51.2 mg/L
Galley (SP-1), Day 4	ND(0.0500) mg/L	37.9 mg/L mg/L
Galley (SP-1), Day 5	0.170 mg/L	5.16 mg/L
Food Pulper (SP-2)	ND(0.0500) mg/L	124 mg/L
Accommodations (SP-3), Day 1	ND(0.0500) mg/L	7.13 mg/L
Accommodations (SP-3), Day 2	ND(0.0500) mg/L	8.84 mg/L
Accommodations (SP-3), Day 3	ND(0.0500) mg/L	11.8 mg/L
Accommodations (SP-3), Day 4	ND(0.0500) mg/L	0.930 mg/L
Accommodations (SP-3), Day 5	ND(0.0500) mg/L	11.4 mg/L
Laundry (SP-4), Day 1	ND(0.0500) mg/L	0.560 mg/L
Laundry (SP-4), Day 2	ND(0.0500) mg/L	0.670 mg/L
Laundry (SP-4), Day 3	ND(0.0500) mg/L	2.55 mg/L
Laundry (SP-4), Day 4	ND(0.0500) mg/L	2.64 mg/L
Laundry (SP-4), Day 5	ND(0.0500) mg/L	0.560 mg/L
Influent to Treatment (SP-5), Day 1	ND(0.0500) mg/L	3.87 mg/L
Influent to Treatment (SP-5), Day 2	ND(0.0500) mg/L	0.760 mg/L
Influent to Treatment (SP-5), Day 3	ND(0.0500) mg/L	83.7 mg/L
Influent to Treatment (SP-5), Day 4	ND(0.0500) mg/L	6.03 mg/L
Influent to Treatment (SP-5), Day 5	ND(0.0500) mg/L	0.310 mg/L
Effluent from Treatment (SP-7), Day 1	ND(0.0500) mg/L	0.780 mg/L
Effluent from Treatment (SP-7), Day 2	ND(0.0500) mg/L	0.760 mg/L
Effluent from Treatment (SP-7), Day 3	ND(0.0500) mg/L	46.3 mg/L
Effluent from Treatment (SP-7), Day 4	ND(0.0500) mg/L	0.155 mg/L
Effluent from Treatment (SP-7), Day 5	ND(0.0500) mg/L	10.3 mg/L
Dried Wastewater Treatment Sludge (SP-9), Day 1	3,480 mg/kg	3,550 mg/kg
Source Water (SP-11), Day 4	ND (0.0500) mg/L	0.660 mg/L

ND - Not detected (number in parenthesis is detection limit).

Table 5-3

Equipment Blank Analytical Results, Norwegian Star

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-11)
Classical Pollutants			
Hardness	mg/L		0.100
Total and Dissolved Metals			
Barium, Total	ug/L		24.8
Copper, Total	ug/L	P120	9.61
Iron, Total	ug/L		82.5
Lead, Total	ug/L	P122	96.5
Manganese, Total	ug/L		4.48
Nickel, Total	ug/L	P124	0.410
Tin, Total	ug/L		0.960
Zinc, Total	ug/L	P128	48.9
Barium, Dissolved	ug/L		0.520
Boron, Dissolved	ug/L		23.1
Manganese, Dissolved	ug/L		1.38
Zinc, Dissolved	ug/L	P128	5.25

< - Average result includes at least one nondetect value.

Table 5-4

Field Duplicate Analytical Results for Classical Pollutants, Total and Dissolved Metals, and Semivolatile Organics, Norwegian Star

Field duplicate analytical results for classical pollutants, 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. 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-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Classical Pollutants								
Alkalinity	mg/L		65503	65527	63.0	63.0	63.0	0.0
Alkalinity	mg/L		65507	65531	63.0	65.0	64.0	3.1
Alkalinity	mg/L		65511	65535	65.0	65.0	65.0	0.0
Ammonia As Nitrogen (NH3-N)	mg/L		65503	65527	ND (0.050)	ND (0.050)	ND (0.050)	NC
Ammonia As Nitrogen (NH3-N)	mg/L		65507	65531	ND (0.050)	ND (0.050)	ND (0.050)	NC
Ammonia As Nitrogen (NH3-N)	mg/L		65511	65535	ND (0.050)	ND (0.050)	ND (0.050)	NC
Available Cyanide	ug/L	P121	65495	65519	ND (2.00)	ND (2.00)	ND (2.00)	NC
Available Cyanide	ug/L	P121	65499	65523	ND (2.00)	ND (2.00)	ND (2.00)	NC
Available Cyanide	ug/L	P121	65503	65527	ND (2.00)	ND (2.00)	ND (2.00)	NC
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		65495	65519	8.26	7.32	7.79	12
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		65499	65523	4.67	5.16	4.92	10
Biochemical Oxygen Demand (BOD_5) (s)	mg/L		65511	65535	5.25	6.97	6.11	28

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Chemical Oxygen Demand (COD)	mg/L		65503	65527	30.0	52.0	41.0	54
Chemical Oxygen Demand (COD)	mg/L		65507	65531	25.0	24.0	24.5	4.1
Chemical Oxygen Demand (COD)	mg/L		65511	65535	28.0	28.0	28.0	0.0
Chloride (s)	mg/L		65503	65527	205	205	205	0.0
Chloride (s)	mg/L		65507	65531	175	185	180	5.6
Chloride (s)	mg/L		65511	65535	175	195	185	11
Hardness (e) (s)	mg/L		65495	65519	34.9	32.8	33.9	6.2
Hardness (e) (s)	mg/L		65499	65523	56.9	56.1	56.5	1.4
Hardness (e) (s)	mg/L		65507	65531	41.8	42.3	42.1	1.2
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65503	65527	0.0890	0.0800	0.0845	11
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65507	65531	0.860	0.0960	0.478	160
Nitrate/Nitrite (NO2-N + NO3-N) (s)	mg/L		65511	65535	ND (0.010)	0.0370	< 0.0235	NC
Settleable Residue	mL/L		65495	65519	ND (0.110)	ND (0.120)	ND (0.115)	NC
Settleable Residue	mL/L		65499	65523	ND (0.110)	ND (0.110)	ND (0.110)	NC
Settleable Residue	mL/L		65511	65535	ND (0.100)	ND (0.100)	ND (0.100)	NC
Sulfate	mg/L		65503	65527	41.4	41.9	41.7	1.2
Sulfate	mg/L		65507	65531	11.4	13.0	12.2	13
Sulfate	mg/L		65511	65535	10.2	8.07	9.14	23
Total Cyanide	mg/L	P121	65495	65519	ND (0.005)	ND (0.005)	ND (0.005)	NC
Total Cyanide	mg/L	P121	65499	65523	ND (0.005)	ND (0.005)	ND (0.005)	NC
Total Cyanide	mg/L	P121	65503	65527	0.0110	ND (0.005)	< 0.00800	NC
Total Dissolved Solids (TDS) (s)	mg/L		65503	65527	327	325	326	0.61

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Total Dissolved Solids (TDS) (s)	mg/L		65507	65531	362	336	349	7.4
Total Dissolved Solids (TDS) (s)	mg/L		65511	65535	376	388	382	3.1
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65503	65527	39.9	52.6	46.3	27
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65507	65531	0.140	0.170	0.155	19
Total Kjeldahl Nitrogen (TKN) (s)	mg/L		65511	65535	0.160	20.4	10.3	200
Total Organic Carbon (TOC)	mg/L		65503	65527	12.0	12.0	12.0	0.0
Total Organic Carbon (TOC)	mg/L		65507	65531	11.1	11.1	11.1	0.0
Total Organic Carbon (TOC)	mg/L		65511	65535	12.8	12.4	12.6	3.2
Total Phosphorus	mg/L		65503	65527	0.710	0.820	0.765	14
Total Phosphorus	mg/L		65507	65531	0.130	0.100	0.115	26
Total Phosphorus	mg/L		65511	65535	0.140	0.140	0.140	0.0
Total Suspended Solids (TSS)	mg/L		65503	65527	ND (5.00)	ND (5.00)	ND (5.00)	NC
Total Suspended Solids (TSS)	mg/L		65507	65531	ND (5.00)	ND (5.00)	ND (5.00)	NC
Total Suspended Solids (TSS)	mg/L		65511	65535	ND (5.00)	6.00	< 5.50	NC
Total and Dissolved Metals								
Aluminum, Total	ug/L		65495	65519	707	470	589	40
Aluminum, Total	ug/L		65499	65523	255	242	249	5.2
Aluminum, Total	ug/L		65507	65531	291	272	282	6.7
Aluminum, Dissolved	ug/L		65499	65523	ND (8.80)	ND (8.80)	ND (8.80)	NC
Aluminum, Dissolved	ug/L		65507	65531	ND (8.80)	10.6	< 9.70	NC
Antimony, Total	ug/L	P114	65495	65519	ND (2.00)	ND (2.00)	ND (2.00)	NC
Antimony, Total, Total	ug/L	P114	65499	65523	ND (2.00)	ND (2.00)	ND (2.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Antimony, Total	ug/L	P114	65507	65531	ND (2.00)	ND (2.00)	ND (2.00)	NC
Antimony, Dissolved	ug/L	P114	65499	65523	ND (2.00)	ND (2.00)	ND (2.00)	NC
Antimony, Dissolved	ug/L	P114	65507	65531	ND (2.00)	ND (2.00)	ND (2.00)	NC
Arsenic, Total	ug/L	P115	65495	65519	ND (2.00)	ND (2.00)	ND (2.00)	NC
Arsenic, Total	ug/L	P115	65499	65523	ND (2.00)	ND (2.00)	ND (2.00)	NC
Arsenic, Total	ug/L	P115	65507	65531	ND (2.00)	ND (2.00)	ND (2.00)	NC
Arsenic, Dissolved	ug/L	P115	65499	65523	ND (2.00)	ND (2.00)	ND (2.00)	NC
Arsenic, Dissolved	ug/L	P115	65507	65531	ND (2.00)	ND (2.00)	ND (2.00)	NC
Barium, Total (e) (s)	ug/L		65495	65519	4.54	4.01	4.28	12
Barium, Total (e) (s)	ug/L		65499	65523	5.76	5.81	5.79	0.86
Barium, Total (e) (s)	ug/L		65507	65531	4.91	5.03	4.97	2.4
Barium, Dissolved (e) (s)	ug/L		65499	65523	5.06	4.91	4.99	3.0
Barium, Dissolved (e) (s)	ug/L		65507	65531	4.92	4.95	4.94	0.61
Beryllium , Total	ug/L	P117	65495	65519	ND (0.070)	ND (0.070)	ND (0.070)	NC
Beryllium, Total	ug/L	P117	65499	65523	ND (0.070)	ND (0.070)	ND (0.070)	NC
Beryllium, Total	ug/L	P117	65507	65531	ND (0.070)	ND (0.070)	ND (0.070)	NC
Boron, Total	ug/L		65495	65519	245	222	234	9.9
Boron, Total	ug/L		65499	65523	223	164	194	30
Boron, Total	ug/L		65507	65531	321	318	320	0.94
Boron, Dissolved (e)	ug/L		65499	65523	158	138	148	14
Boron, Dissolved (e)	ug/L		65507	65531	350	368	359	5.0
Cadmium, Total	ug/L	P118	65495	65519	ND (0.080)	ND (0.080)	ND (0.080)	NC

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Cadmium, Total	ug/L	P118	65499	65523	ND (0.080)	ND (0.080)	ND (0.080)	NC
Cadmium, Total	ug/L	P118	65507	65531	ND (0.080)	ND (0.080)	ND (0.080)	NC
Cadmium, Dissolved	ug/L	P118	65499	65523	ND (0.080)	ND (0.080)	ND (0.080)	NC
Cadmium, Dissolved	ug/L	P118	65507	65531	ND (0.080)	ND (0.080)	ND (0.080)	NC
Calcium, Total (s)	ug/L		65495	65519	8,620	8,080	8,350	6.5
Calcium, Total (s)	ug/L		65499	65523	9,120	9,100	9,110	0.22
Calcium, Total (s)	ug/L		65507	65531	9,980	10,100	10,000	1.2
Calcium, Dissolved (s)	ug/L		65499	65523	8,780	8,330	8,560	5.3
Calcium, Dissolved (s)	ug/L		65507	65531	10,000	9,880	9,940	1.2
Chromium, Total	ug/L	P119	65495	65519	0.440	0.720	0.580	48
Chromium, Total	ug/L	P119	65499	65523	ND (0.270)	ND (0.270)	ND (0.270)	NC
Chromium, Total	ug/L	P119	65507	65531	ND (0.270)	ND (0.27)	ND (0.270)	NC
Chromium, Dissolved	ug/L	P119	65499	65523	ND (0.270)	ND (0.270)	ND (0.270)	NC
Chromium, Dissolved	ug/L	P119	65507	65531	ND (0.270)	ND (0.270)	ND (0.270)	NC
Cobalt, Total	ug/L		65495	65519	ND (0.660)	ND (0.660)	ND (0.660)	NC
Cobalt, Total	ug/L		65499	65523	ND (0.660)	ND (0.660)	ND (0.660)	NC
Cobalt, Total	ug/L		65507	65531	ND (0.660)	ND (0.660)	ND (0.660)	NC
Cobalt, Dissolved (s)	ug/L		65499	65523	2.44	ND (0.660)	< 1.55	NC
Cobalt, Dissolved (s)	ug/L		65507	65531	2.40	ND (0.660)	< 1.53	NC
Copper, Total (e) (s)	ug/L	P120	65495	65519	12.8	9.80	11.3	27
Copper, Total (e) (s)	ug/L	P120	65499	65523	7.99	8.33	8.16	4.2
Copper, Total (e) (s)	ug/L	P120	65507	65531	8.33	8.16	8.25	2.1

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Copper, Dissolved (s)	ug/L	P120	65499	65523	5.57	5.38	5.48	3.5
Copper, Dissolved (s)	ug/L	P120	65507	65531	5.27	5.62	5.45	6.4
Iron, Total (e) (s)	ug/L		65495	65519	459	327	393	34
Iron, Total (e) (s)	ug/L		65499	65523	305	305	305	0.0
Iron, Total (e) (s)	ug/L		65507	65531	288	304	296	5.4
Iron, Dissolved	ug/L		65499	65523	ND (9.80)	ND (9.80)	ND (9.80)	NC
Iron, Dissolved	ug/L		65507	65531	29.3	24.3	26.8	19
Lead, Total (e)	ug/L	P122	65495	65519	1.93	1.74	1.84	10
Lead, Total (e)	ug/L	P122	65499	65523	1.47	ND (0.620)	< 1.05	NC
Lead, Total (e)	ug/L	P122	65507	65531	ND (0.620)	ND (0.620)	ND (0.620)	NC
Lead, Dissolved	ug/L	P122	65499	65523	ND (0.620)	ND (0.620)	ND (0.620)	NC
Lead, Dissolved	ug/L	P122	65507	65531	ND (0.620)	ND (0.620)	ND (0.620)	NC
Magnesium, Total (s)	ug/L		65495	65519	3,260	3,060	3,160	6.3
Magnesium, Total (s)	ug/L		65499	65523	8,280	8,110	8,200	2.1
Magnesium, Total (s)	ug/L		65507	65531	4,100	4,150	4,130	1.2
Magnesium, Dissolved (s)	ug/L		65499	65523	8,090	7,710	7,900	4.8
Magnesium, Dissolved (s)	ug/L		65507	65531	4,160	4,110	4,140	1.2
Manganese, Total (e) (s)	ug/L		65495	65519	18.8	17.3	18.1	8.3
Manganese, Total (e) (s)	ug/L		65499	65523	20.1	20.2	20.2	0.50
Manganese, Total (e) (s)	ug/L		65507	65531	16.9	17.1	17.0	1.2
Manganese, Dissolved (e) (s)	ug/L		65499	65523	22.7	18.4	20.6	21
Manganese, Dissolved (e) (s)	ug/L		65507	65531	20.1	17.0	18.6	17

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Mercury, Total	ug/L	P123	65495	65519	ND (0.050)	ND (0.050)	ND (0.050)	NC
Mercury, Total	ug/L	P123	65499	65523	ND (0.050)	ND (0.050)	ND (0.050)	NC
Mercury, Total	ug/L	P123	65507	65531	ND (0.050)	ND (0.050)	ND (0.050)	NC
Molybdenum, Total	ug/L		65495	65519	ND (1.60)	ND (1.60)	ND (1.60)	NC
Molybdenum, Total	ug/L		65499	65523	ND (1.60)	ND (1.60)	ND (1.60)	NC
Molybdenum, Total	ug/L		65507	65531	ND (1.60)	ND (1.60)	ND (1.60)	NC
Molybdenum, Dissolved	ug/L		65499	65523	ND (1.60)	ND (1.60)	ND (1.60)	NC
Molybdenum, Dissolved	ug/L		65507	65531	ND (1.60)	ND (1.60)	ND (1.60)	NC
Nickel, Total (e) (s)	ug/L	P124	65495	65519	17.8	17.1	17.5	4.0
Nickel, Total (e) (s)	ug/L	P124	65499	65523	12.6	13.5	13.1	6.9
Nickel, Total(e) (s)	ug/L	P124	65507	65531	8.58	8.93	8.76	4.0
Nickel, Dissolved (s)	ug/L	P124	65499	65523	12.2	11.2	11.7	8.5
Nickel, Dissolved (s)	ug/L	P124	65507	65531	8.71	8.33	8.52	4.5
Selenium, Total	ug/L	P125	65495	65519	ND (1.40)	ND (1.40)	ND (1.40)	NC
Selenium, Total	ug/L	P125	65499	65523	ND (1.40)	ND (1.40)	ND (1.40)	NC
Selenium, Total	ug/L	P125	65507	65531	ND (1.40)	ND (1.40)	ND (1.40)	NC
Selenium, Dissolved	ug/L	P125	65499	65523	ND (1.40)	ND (1.40)	ND (1.40)	NC
Selenium, Dissolved	ug/L	P125	65507	65531	ND (1.40)	ND (1.40)	ND (1.40)	NC
Silver, Total	ug/L	P126	65495	65519	ND (0.770)	ND (0.770)	ND (0.770)	NC
Silver, Total	ug/L	P126	65499	65523	ND (0.770)	ND (0.770)	ND (0.770)	NC
Silver, Total	ug/L	P126	65507	65531	ND (0.770)	ND (0.770)	ND (0.770)	NC

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Sodium, Total (s)	ug/L		65495	65519	66,500	61,100	63,800	8.5
Sodium, Total (s)	ug/L		65499	65523	102,000	97,800	99,900	4.2
Sodium, Total (s)	ug/L		65507	65531	68,400	68,700	68,600	0.44
Sodium, Dissolved (s)	ug/L		65499	65523	95,500	90,600	93,100	5.3
Sodium, Dissolved (s)	ug/L		65507	65531	62,200	61,500	61,900	1.1
Thallium, Total	ug/L	P127	65495	65519	ND (0.800)	ND (0.800)	ND (0.800)	NC
Thallium, Total	ug/L	P127	65499	65523	ND (0.800)	ND (0.800)	ND (0.800)	NC
Thallium, Total	ug/L	P127	65507	65531	ND (0.800)	ND (0.800)	ND (0.800)	NC
Tin, Total (e)	ug/L		65495	65519	ND (0.940)	ND (0.940)	ND (0.940)	NC
Tin, Total (e)	ug/L		65499	65523	ND (0.940)	ND (0.940)	ND (0.940)	NC
Tin, Total (e)	ug/L		65507	65531	ND (0.940)	ND (0.940)	ND (0.940)	NC
Tin, Dissolved	ug/L		65499	65523	ND (0.940)	ND (0.940)	ND (0.940)	NC
Tin, Dissolved	ug/L		65507	65531	ND (0.940)	ND (0.940)	ND (0.940)	NC
Titanium, Total	ug/L		65495	65519	ND (0.620)	ND (0.620)	ND (0.620)	NC
Titanium, Total	ug/L		65499	65523	ND (0.620)	ND (0.620)	ND (0.620)	NC
Titanium, Total	ug/L		65507	65531	ND (0.620)	ND (0.620)	ND (0.620)	NC
Vanadium, Total	ug/L		65495	65519	ND (0.470)	ND (0.470)	ND (0.470)	NC
Vanadium, Total	ug/L		65499	65523	ND (0.470)	ND (0.470)	ND (0.470)	NC
Vanadium, Total	ug/L		65507	65531	ND (0.470)	ND (0.470)	ND (0.470)	NC
Vanadium, Dissolved	ug/L		65499	65523	ND (0.470)	ND (0.470)	ND (0.470)	NC
Vanadium, Dissolved	ug/L		65507	65531	ND (0.470)	ND (0.470)	ND (0.470)	NC

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-4 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original Effluent from Treatment (SP-7) (b)	Duplicate Effluent from Treatment (SP-8) (b)	Average	Relative Percent Difference
Yttrium, Total	ug/L		65495	65519	ND (0.310)	ND (0.310)	ND (0.310)	NC
Yttrium, Total	ug/L		65499	65523	ND (0.310)	ND (0.310)	ND (0.310)	NC
Yttrium, Total	ug/L		65507	65531	ND (0.310)	ND (0.310)	ND (0.310)	NC
Zinc, Total (e) (s)	ug/L	P128	65495	65519	597	555	576	7.3
Zinc, Total (e) (s)	ug/L	P128	65499	65523	744	749	747	0.67
Zinc, Total (e) (s)	ug/L	P128	65507	65531	633	643	638	1.6
Zinc, Dissolved (e)	ug/L	P128	65499	65523	667	631	649	5.5
Zinc, Dissolved (e)	ug/L	P128	65507	65531	619	608	614	1.8
Semivolatile Organics								
Bis(2-ethylhexyl)phthalate	ug/L	P066	65495	65519	ND (10.0)	ND (10.0)	ND (10.0)	NC
Bis(2-ethylhexyl)phthalate	ug/L	P066	65499	65523	ND (10.0)	ND (10.0)	ND (10.0)	NC
Bis(2-ethylhexyl)phthalate	ug/L	P066	65503	65527	ND (10.0)	ND (10.0)	ND (10.0)	NC
Diethyl Phthalate	ug/L	P070	65495	65519	ND (10.0)	ND (10.0)	ND (10.0)	NC
Diethyl Phthalate	ug/L	P070	65499	65523	ND (10.0)	ND (10.0)	ND (10.0)	NC
Diethyl Phthalate	ug/L	P070	65503	65527	ND (10.0)	ND (10.0)	ND (10.0)	NC
Phenol (s)	ug/L	P065	65495	65519	66.0	57.0	61.5	15
Phenol (s)	ug/L	P065	65499	65523	32.0	62.0	47.0	64
Phenol (s)	ug/L	P065	65503	65527	65.0	69.0	67.0	6.0

(a) Sample numbers identify corresponding analytical results in Appendix 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 5-3 for equipment blank results.
(s) Analyte detected at some level in the source water. See Section 4.1.7 and Table 4-12 for source water results.
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.
< - Average result includes at least one nondetect value (calculation uses detection limits for nondetected results).

Table 5-5

Field Duplicate Analytical Results for Pathogen Indicators and Volatile Organics, Norwegian Star

Field duplicate analytical results presented for pathogen indicators and volatile organics detected at least once during the sampling episode. Field duplicate samples were collected sequentially from the same source, stored, and analyzed independently. See Figure 2-2 for sampling point locations. Also listed are 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 (b) Effluent from Treatment (SP-7)	Duplicate (b) Effluent from Treatment (SP-8)	Average	Relative Percent Difference
Pathogen Indicators								
E. coli	MPN/100 mL		65496	65558	ND (1.00)	ND (1.00)	ND (1.00)	NC
E. coli	MPN/100 mL		65500	65559	ND (1.00)	ND (1.00)	ND (1.00)	NC
E. coli	MPN/100 mL		65508	65560	ND (1.00)	ND (1.00)	ND (1.00)	NC
E. coli	MPN/100 mL		65495	65519	ND (1.00)	ND (1.00)	ND (1.00)	NC
E. coli	MPN/100 mL		65499	65523	ND (1.00)	ND (1.00)	ND (1.00)	NC
E. coli	MPN/100 mL		65503	65527	ND (1.00)	ND (1.00)	ND (1.00)	NC
E. coli	MPN/100 mL		65507	65531	ND (1.00)	ND (1.00)	ND (1.00)	NC
Enterococci	MPN/100 mL		65496	65558	ND (1.00)	ND (1.00)	ND (1.00)	NC
Enterococci	MPN/100 mL		65500	65559	ND (1.00)	ND (1.00)	ND (1.00)	NC
Enterococci	MPN/100 mL		65508	65560	ND (1.00)	ND (1.00)	ND (1.00)	NC
Enterococci	MPN/100 mL		65495	65519	ND (1.00)	ND (1.00)	ND (1.00)	NC
Enterococci	MPN/100 mL		65499	65523	ND (1.00)	ND (1.00)	ND (1.00)	NC
Enterococci	MPN/100 mL		65503	65527	ND (1.00)	ND (1.00)	ND (1.00)	NC
Enterococci	MPN/100 mL		65507	65531	ND (1.00)	ND (1.00)	ND (1.00)	NC
Fecal Coliform	CFU/100 mL		65496	65558	ND (2.00)	ND (2.00)	ND (2.00)	NC
Fecal Coliform	CFU/100 mL		65500	65559	ND (2.00)	ND (2.00)	ND (2.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
EXCLUDE - Data excluded from the data set (see data review narratives in Appendix D for details).
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.

Table 5-5 (Continued)

Analyte	Unit	Priority Pollutant Code	Sample Numbers (a)		Original (b) Effluent from Treatment (SP-7)	Duplicate (b) Effluent from Treatment (SP-8)	Average	Relative Percent Difference
Fecal Coliform	CFU/100 mL		65508	65560	ND (2.00)	ND (2.00)	ND (2.00)	NC
Fecal Coliform	CFU/100 mL		65495	65519	ND (2.00)	ND (2.00)	ND (2.00)	NC
Fecal Coliform	CFU/100 mL		65499	65523	ND (2.00)	ND (2.00)	ND (2.00)	NC
Fecal Coliform	CFU/100 mL		65503	65527	ND (2.00)	ND (2.00)	ND (2.00)	NC
Fecal Coliform	CFU/100 mL		65507	65531	EXCLUDE	ND (2.00)	ND (2.00)	NC
Volatile Organics								
Bromodichloromethane	ug/L	P048	65495	65519	ND (5.00)	ND (5.00)	ND (5.00)	NC
Bromodichloromethane	ug/L	P048	65499	65523	ND (5.00)	ND (5.00)	ND (5.00)	NC
Bromodichloromethane	ug/L	P048	65503	65527	ND (5.00)	ND (5.00)	ND (5.00)	NC
Chloroform	ug/L	P023	65495	65519	ND (5.00)	ND (5.00)	ND (5.00)	NC
Chloroform	ug/L	P023	65499	65523	ND (5.00)	ND (5.00)	ND (5.00)	NC
Chloroform	ug/L	P023	65503	65527	ND (5.00)	ND (5.00)	ND (5.00)	NC
Ethylbenzene	ug/L	P038	65495	65519	ND (5.00)	ND (5.00)	ND (5.00)	NC
Ethylbenzene	ug/L	P038	65499	65523	ND (5.00)	ND (5.00)	ND (5.00)	NC
Ethylbenzene	ug/L	P038	65503	65527	ND (5.00)	ND (5.00)	ND (5.00)	NC
Toluene	ug/L	P086	65495	65519	ND (5.00)	ND (5.00)	ND (5.00)	NC
Toluene	ug/L	P086	65499	65523	ND (5.00)	ND (5.00)	ND (5.00)	NC
Toluene	ug/L	P086	65503	65527	ND (5.00)	ND (5.00)	ND (5.00)	NC

(a) Sample numbers identify corresponding analytical results in Appendices A-1 and A-2.
(b) Sampling point location; see Figure 2-2.
EXCLUDE - Data excluded from the data set (see data review narratives in Appendix D for details).
ND - Not detected (number in parentheses is detection limit).
NC - Not calculated because one or both of the sample results is less than the laboratory detection limit.

6.0 REFERENCES

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