SOURCE REDUCTION SUMMARY REPORT

June 9 2010

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INTRODUCTION

This paper is a brief overview of information provided by cruise ships lines regarding their wastewater operations during the 2008-2009 cruise season in the form of Source Reduction Evaluation Plans (SRE). The idea is to provide you with a concise global overview of the operator's efforts in the 2008-2009 cruise seasons to reduce pollution levels from the wastewater discharges.

The pollutants of interest in the 2008 and 2010 General Permits are Ammonia, copper, Nickel, and Zinc. Vessel operators submitted SRE reports and other relevant information. This document includes the Department's review process of the available documentation and includes general descriptions of the vessel's operations.

This document does not contain all information included in the actual SRE reports, but is instead a selection of the most important highlights of the SRE reports presented for the purpose of instigating more detailed discussion.

Readers are encouraged to read the provided SRE information, and the Vessel/Cruise Line reporting and responses on questions from ADEC. A copy of the 2008 ADEC Technology Workshop Report includes good information regarding the AWTS technology as currently used on board of the vessels. See Link:

http://www.dec.state.ak.us/water/cruise_ships/pdfs/2_16_09_Feasibility_Report_Draft_Web.pdf

1. MINIMUM REQUIREMENTS FOR SRE REPORTING

SRE actions were required for Permit holders of the General Permit (No.2007DB002). In order for a Permittee to be granted approval to discharge under the less stringent interim effluent limits, the Permittee was required to submit a Source Reduction Evaluation Plan for ADEC approval. These plans were required to include as a minimum[1]:

1.1. Goals of Source Reduction Evaluation

- (e.g. identification of potential sources for each parameter, ammonia, copper etc., action plans, reporting of success or failure)

1.2. Guidelines for the Source Reduction Evaluation

- Source Identification
- Use of chemicals, pesticides, drinking water supplies; leaching of metals etc.
    - Additional Items to characterize the quality of the influent:
    - Identification of chemicals, pipe degreasers, pipe cleaners for cleaning hotel GW and BW systems, specification(s) vessel systems that deliver influent to the WW treatment systems,;
    - Identification of materials used in the water piping system, corrosion items, characteristics of the technical or condensate water;
    - Identification technical water piping system;
    - Identification of the volumes of bunkered water, bunker water locations, and possible used additives use in potable water.
- Identification mixing ratio of sewage and gray water influent before treatment, discuss whether changing this mixing ratio affect effluent quality
- Identification of the materials used in the internal coating of potable water holding tanks, and holding tanks waste water treatment process used tanks, and influence on potable water quality
- Discuss potential impacts of operational / equipment changes to reduce pollutant of concern related to environmental / public health concerns

[1] ADEC Alaska Cruise Ship Association/ Northwest Cruise Ship Association "Large Commercial Passenger Vessel Waste water Discharge General Permit No. 2007DB002" Dated: April 18, 2008

1.3. Implementation Plan

- SRE Plan implementation was required to include a schedule to meet the long and short term effluent limits, and could include both operational and/or equipment changes.
- Adoption of operational practices to reduce pollutants (e.g. Alternative cleaning products) and substitution of non chemical products for methods that involve chemicals.
- This portion of the SRE should also address new or additional technologies to reduce the levels of pollutant. This research effort may be tailored to a specific vessel, cruise line or may apply to the industry as a whole and may include space requirements, maintenance costs, reliability, energy requirements, etc.

1.4. Reporting

- Vessels with approved SRE plans were required to provide an annual progress report at the end of the year

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2. CARNIVAL CRUISE LINES SRE OVERVIEW

Table C1 provides an overview of the Carnival Cruise Lines (CCL) provided documentation for the 2008 and 2009 cruise season. Please note this includes a global overview of the documentation.

Table C1
2008 2009 Season
SRE CCL Documentation Global Overview

Cruise Line	Reports Year 2008	Reports Year 2009	ADEC Questions Comments	Cruise Line Response	ADEC Summary
CCL	Yes S 7/11/08		Yes L 7/28/08	Yes D 8/18/08	-
	Yes D 8/18/08		-	-	Yes ADEC CCL Review SRE update 8/18/08
	Yes A 2/6/09*		Yes E 2/4/09	Yes E 2/2/09	No exceedance 2008 [pH 1^]
		Yes A 1/14/10	-	-	Yes ADEC CCL Review SRE 1/14/10

Note: * = Date of report; A = Annual Report; S = Start SRE application; L = Letter; D = Document; and PR = Pre Season Report; ^ = 2008 only one exceedance pH.

2.1. Global Elements Summary of the Submitted SRE Report 2008 2009

The main groups of SRE items for CCL are listed below in Table C2; group items were used by most, if not all, operators in their SRE related reporting in 2008 and 2009. CCL provided brief SRE reporting.

Table C2
2008 2009 Season
Reporting SRE CCL Main Groups

Main Group	
	Description concise
I. Influent Source Reduction	[waste water flows to AWTS System]
a. Source Water Evaluation	[sources contributing]
b. Chemical Use / Process Evaluation	[use of Hotel Engine room Chemicals]
c. Water Supply Evaluation	[evaporator / Bunker water / Treatment]
II. Treatment Technology Evaluation / Implementation	[new / improved technology]
III. AWTS operations / optimalization / data	[AWTS specific]

2.1.1. General Vessel Operations

This section describes water and bunkering operations, etc. All operations described are in relation to the SRE plans.

2.1.2. Vessel SRE Items Reports Results

This section describes vessel operations assessed per fleet and/or cruise line.

Table 1 provides an overview of the cruise lines that provided SRE reports and performed actions on board. Table C3 below lists all vessels in the CCL fleet that gave a description of the reported SRE items.

Table C3
2008 / 2009 CCL Fleet Status*

2008 2009 Season:	Vessel Name	Year Delivery	AWTS Type / Units Cap m3	2008 Discharge Status	2009 Discharge Status
	Carnival Spirit	2001	Rochem 740 (GW)	D [only GW]	D [only GW]
Notes: ND=Non Discharger D=Discharger *=Vessels that participated in SRE Reporting per season.					

2.2. Influent Source Reduction

2.2.1. Source water evaluation

Three main groups:

- Bunkered water from Shore facilities;
- Evaporator water produced on board; and
- Technical water produced on board.

The CCL Alaskan fleet consists of one vessel (Carnival Spirit). Sampling of bunker quality is included in the ACA reporting Section 9. The results of the bunker water source evaluation are discussed separately.

In 2009, CCL confirmed the industry potable water testing program (see ACA potable water overview in Section 9) was completed. According to the results, CCL avoided bunkering as much as possible at ports where potable water contained extremely high levels of metals. Atlas fresh water evaporators and RO systems are installed on board the vessel. Bunker lines on board (from fill point on shore to the potable water bunker tanks) consist of galvanized piping. CCL initially planned on selective bunkering and avoided ports with high metal loads in bunker water.

Notes:

- Chemicals are most likely used in the evaporator system. It appears that these chemicals are used in the overboard circuit from the evaporator, and it is not known if the chemicals are “carried over” into the potable water circuit. Also, it is not known if chemicals are used in the evaporator on the “distilled water side” (potable water circuit).
- Tank coatings of the potable water systems storage are not clearly identified.

- o Optimization of bunkered versus evaporated water sourcing/evaluation: sampling does not appear to have been completed. Potable water balancing: potable water use and evaporator water use is either not conducted or was not included in the SRE.
- o ADEC was not aware of any communications or progress made by the ACA regarding the review of piping systems on the port facilities. (See ACA study for further information).
- o Potable water treatment, like neutralization acidity, restores necessary salts and hardness to distilled water to make it palatable, prevents the formation of sediments, and inhibits corrosion.
- o CCL did include limited, estimated project bunkered water volumes and correlations to the RO water; specific bunker water ports could not be made.
- o At the end of the 2009 reporting season, CCL initiated industry discussions regarding the feasibility of the bunker water infrastructure in ports.
- o CCL did not include or explain in detail which technologies are used in the CCL's policy regarding potable water treatment.

Table C4
CCL Alaska Fleet Water
2008 2009 Operations [average]

Vessel	Evaporator Average day m3/day	RO water maker Cap day m3/day	Average condensate TG m3/day	Bunker Ports AK loading Volume %	Bunker Port Vancouver Volume %
Carnival Spirit	1200 [2x600]	NP	NP	75	25
2008					
Treated waste water discharged volumes 2008 m3		July	September	August	
Carnival Spirit		310	434	967	
*Note: NP = NP Provided and Alaska Bunker Ports not identified					

Technical Water

- CCL did identify the use or presence of technical water in detail. In later responses, CCL stated that technical water was also used in laundry operations, but will likely cease to use technical water in this way.
- CCL believes that technical water is an "immaterial" amount of the total water used, and in most cases is not used except on one ship.

2.2.1.1. Chemical Use/Process Evaluation

Actions included in SRE

- CCL is closely monitoring cleaning materials present in waste streams.
- CCL does not use de-scaling chemicals for internal pipe cleaning.

Note:

- Product substitution and implementation of a new chemicals inventory was not included in initial SRE.
- Discussion regarding the use and type of chemicals was absent or extremely limited.

2.3. Treatment Technology Evaluation/Implementation

The CCL vessel has the Rochem system installed on board. The Carnival Spirit is the only vessel in the Alaskan fleet that consistently used the Rochem GW system in 2008 and 2009. The use included selected GW stream for treatment.

Evaluation

CCL did not evaluate other systems in detail; it stated only that the Rochem system was used.

Note:

- Details for specific AWTS and operations for each system were not provided.
- CCL did not expand on the idea that RO also can reduce metals and metal loads.

Table C5
GW Generation Carnival Spirit
Vessel per VSSP - NOI

Vessel	Pax	Crew	GW VSSP m3/day	GW generation person /day gal	AWTS System Cap m3/day
Carnival Spirit*	2125	934	980		740
*=BW not treated > 12 nm; GW only treated (selected streams)					

3. HOLLAND AMERICA LINE SRE OVERVIEW

Table H1 provides an overview of documentation provided by Holland America Line (HAL) for the 2008 and 2009 cruise season. Please note this include a global overview of the documentation.

Table H1
2008 2009 Season
SRE HAL Documentation Global Overview

Cruise Line	Reports Year 2008	Reports Year 2009	ADEC Questions Comments	Cruise Line Response	ADEC Summary
HAL	Yes S/4/24/08		Yes L 7/25/08 Yes	Yes LD 8/18/08	Yes ADEC HAL Review SRE update 8/18/08
	Yes A/1/14/09*		Yes E 1/27/09	Yes LD 2/23/09	-
	-		Yes L 3/17/09	Yes E 3/20/09	-
	-		Yes L 3/31/09	-	-
		Yes PR 4/30/09	Yes L 9/9/09	Yes LD 9/11/09	-
		Yes A 11/17/09	-	-	-
		Yes A 1/14/10*	-	-	Yes ADEC HAL Review SRE 1/14/10

Note: *=Date of report; A=Annual Report; S=Start SRE application; D=Document; and PR=Pre Season Report

3.1. Global Elements Summary of the Submitted SRE Report 2008 2009:

The main groups of SRE items for HAL are listed below in Table H1; group items were used by most, if not all, operators in their SRE related reporting in 2008 and 2009. CCL provided brief SRE reporting. Please note that not all operators adhered to a similar reporting style in their reports; this made the process of reviewing and comparing SRE reports more complex.

Table H1
2008 2009 Season
Reporting SRE HAL Main Groups

Main Group	
	Description concise
I. Influent Source Reduction	[waste water flows to AWTS System]
a. Source Water Evaluation	[sources contributing]
b. Chemical Use/Process Evaluation	[use of Hotel Engine room Chemicals
c. Water Supply Evaluation	[evaporator/bunker water/Treatment]
II. Treatment Technology Evaluation/Implementation	[new/improved technology]
III. AWTS operations/optimalization/data	[AWTS specific]

3.1.1. General Vessel Operations

Describes the water/bunkering etc. All operations described are in relation to the SRE plans.

3.1.2. Vessel SRE Items Reports Results

This section includes a very concise description of the vessel operations assessed per fleet/cruise line.

Table 1 provides an overview of the cruise lines that provided SRE reports and performed actions on board; below is for each cruise line per season a concise description given of the reported SRE items and which specific vessel information was obtained.

Table H2
2008/2009 HAL Fleet Status

2008 2009 Season:	Vessel Name	Year Delivery	AWTS Type	2008 Discharge Status	2009 Discharge Status
	Oosterdam Westerdam Zuiderdam (Vista Class)	Oosterdam 2003 Westerdam 2005 Zuiderdam 2002	Rochem	Oosterdam ND Westerdam BW only No visit 2008 season	No Visit 2009 season Westerdam ND Zuiderdam ND
	Ryndam Statendam Veendam (S Class)	Ryndam 1994 Statendam 1993 Veendam 1996	Zenon	Ryndam D Statendam D Veendam D	Ryndam D Statendam D Veendam ND
	Volendam Zaandam Amsterdam (R Class)	Volendam 1999 Zaandam 2000 Amsterdam 2000	Zenon N/A	Volendam D Zaandam D Amsterdam ND	Volendam ND+ Zaandam D Amsterdam ND
Notes: ND=Non Discharger D=Discharger +=Discharged 2009 May Only					

2008 season:

3.2. Influent Source Reduction

3.2.1. Source water evaluation

Three main groups:

- Bunkered water from Shore facilities;
- Evaporator water produced on board; and
- Technical water produced on board.

HAL provided a description of potable water origin; potable water can be bunkered, and produced on board by using evaporators which desalinate seawater. In Alaska is all the water bunkered at the major cruise ports. Outside the state, Seattle (WA) and Vancouver (BC) are ports where the HAL vessels take on bunker water as well.

- HAL Fleet 2008 Potable water Bunkering:

  In 2008 HAL Fleet bunkered on average per SE Alaska Ports and including Seward, in the range approximately between the 50 tons (metric) – 1,300 tons (metric). Water bunkering per Port depends on water need, the itinerary, and the available bunker time the vessel is in Port. The HAL fleet bunkered potable water for all the vessels in 2008 in each major cruise ports in Alaska (except for ports were vessels were at anchorage).

- HAL Fleet Water Sourcing 2008:

  Sourcing in this context means the source of the potable water, this water can be bunkered water or water produced on board (evaporator). The total volume of water made on board in comparison of the total water volume is identified in Table H3, which lists the water sources per ship and bunkered location. In 2008 the HAL fleet produced between approximately 31 – 78 % percent of the potable water with the on board evaporators.

Table H3
HAL Fleet 2008
Potable Water Sources Volumes Percentage

Vessel	Produced Water Volume %		2008 Season Bunkered Water Volume % Port							Vessel Class
	E water	T water	SEA	VAN	KTN	JNU	SKG	HNS	SWD	
Oosterdam	78	-	5	-	11	7	-	-	-	V-Class
Westerdam	81	-	-	-	12	7	-	-	-	V-Class
Ryndam	34	13	-	15	19	6	13	-	-	S-Class
Statendam	52	-	-	24	14	1	9	-	-	S-Class
Veendam	31	-	-	18	19	6	8	3	15	S-Class
Volendam	47	2	-	6	10	7	4	9	16	R-Class
Zaandam	41	-	-	4	13	9	5	10	17	R-Class

Table H3A
HAL Fleet 2009
Potable Water Sources Volumes Percentage

Vessel	Produced Water Volume %		2009 Season** Bunkered Water Volume % Port								Vessel Class
	E water	T water	SEA	VAN	KTN	JNU	SKG	HNS	SWD	VIC	
Amsterdam	ND		-								R-Class
Oosterdam	-		No visit in 2009 season								V-Class
Westerdam	ND		Sources not Reported no comparison possible								V-Class
Ryndam I	32	Note!	-	10	18	25	6	-	9	-	S-Class
Ryndam II	25	Note!	-	10	14	31	5	-	15	-	S-Class
Statendam I	55	Note!	-	10	7	20	-	4	-	4	S-Class
Statendam II	76	Note!	-	7	4	7	4	2	-	-	S-Class
Veendam	-		Sources not Reported no comparison possible								S-Class
Volendam	-		Sources not Reported no comparison possible								R-Class

Zaandam I	59	Note!	9	2	14	15	-	-	-	1	R-Class
Zaandam II	71	Note!	3	-	16	10	-	-	-	-	R-Class
Zuiderdam	-		Sources not Reported no comparison possible								V-Class

Notes: **= Reported Graphs very hard to read/scaled percentage from graphs (approximate)

E water = Evaporator water made on board; T water = Technical water made on board.

SEA=Seattle (WA); VAN=Vancouver (BC); Alaskan Ports: KTN=Ketchikan; JNU=Juneau; SKG=Skagway; HNS=Haines; SWD=Seward. ND=Non discharger

I=phase I May /June/July 2009; II=phase II August/September 2009

Note: Technical Water Volume % not specified /identified

Evaporator Systems/Water HAL Fleet Class Description

S and R Class Vessels

- Four stage water evaporators using engine (jacket cooling water) for heating. Additional steam heating is possible.
- Materials specifications of the evaporator system were not provided.
- Potable water flows from the evaporators to the potable water/technical water storage tanks for further distribution to the users on board;
- The distribution (risers) is done through Cunifer piping material/polypropylene piping.

Evaporator/Bunker water treatment

- The Evaporator water has typical low pH, and the pH is adjusted in Culligan water treatment system, to approximately 7.3 pH. The Culligan water treatment system, consists a mix of calcium carbonate and magnesium oxide, it also contributes to water hardening. However this is not the primary goal of the unit, this is pH improvement.
- Potable water is also chlorinated to 2.2 and 2.5 ppm chlorine by automated dosing system.
- Tank coatings of the potable water systems are made of the two part epoxy system (International Paints Epoxy Interline White).
- From the potable water tanks by means of risers (Cunifer material) piping is the water distributed to the decks levels, from there is the water distributed (laterally) to the consumers by polypropylene plumbing.
- Loro-X piping, galvanized steel pipe with coating is used for drainage below the main decks.

- Evaporators are not equipped with corrosion control mechanisms.

Notes:

- Water that has already acceptable pH is not treated does not receive pH treatment. HAL did not include the process how this established;
- Detailed description of this pH adjusting system and current treatment status /operations not identified.
- Piping materials from the "shore connections" (bunker water) to the potable water storage tanks on board of the vessel, the "inter piping" between storage tanks, and valves, fittings and pumps materials were not identified in the description(s). HAL did not include these items in their evaluation because they are too numerous to sample economically.

Vista Class Vessels

- Multistage stage water evaporators using engine (jacket cooling water) for heating and additional steam heating is possible.
- Materials specifications of the evaporator system was provided, it was identified that evaporator included titanium plate parts and that the re-condensation section contained copper alloys.
- Potable water flows from the evaporators to the potable water/technical water storage tanks for further distribution to the users on board;
- The distribution (risers) is done through stainless steel piping material/polypropylene piping.

Evaporator/Bunker water treatment

- The water treatment (pH) conditioning and chlorination is done as per R and S Class.
- Tank coatings of the potable water systems are made of the phenolic epoxy system (Sigma, and Hempel Coatings).
- From the potable water tanks by means of risers (stainless steel material) piping is the water distributed to the decks levels, from there is the water distributed (laterally) to the consumers by polypropylene plumbing.
- Loro-X piping, galvanized steel pipe with coating is used for drainage below the main decks.

Notes:

- Detailed description of this pH adjusting system and current treatment status /operations not identified.
- HAL believes that the current water quality characteristics (soft) does not warrant correction, and if needed post-use treatment technology development should be used to meet those limits..
- Piping materials form the "shore connections" (bunker water) to the potable water storage tanks, inter piping between storage tanks, valves, fittings and pumps materials were not identified in the description(s) reporting. HAL did not include these items in their evaluation because they are too numerous to sample economically.
- Nickel is a component (alloy) of austenitic steel, stainless steel; HAL could not pinpoint any specific source to which nickel concentrations may be accountable at this time.

Technical Water

- For use in engine spaces, some cleaning and for Vista Class conveyance water toilets ("flushing water").
- Technical water include, air conditioning condensate, bunkered water, evaporator water;
- Technical water is not conditioned/managed for pH etc.
- EPA studies did not evaluate Technical water;

Note:

- HAL uses on the R, S, and Vista Class vessels potions of technical water to service laundry operations, pending on considerations, water savings etc. These uses, flow data etc. are not tracked by HAL.
- For Vista ships is about 60 m3 technical water is used to flush the toilets.

Actions included in SRE

- Strategic sourcing of bunkered water was included in initial SRE; See Notes.
- Optimization of bunkered versus evaporated water sourcing; See Notes.
- Sampling of bunker quality (ACA report). The results of this source evaluation are separately discussed. HAL did not "independently" gather bunker waters samples in 2008 and 2009.
- On board sampling on the Statendam (S Class) Zaandam (R Class), Westerdam (Vista Class) on the following sources as set out in Table

H3. Sample Analytes included: Ammonia, copper, Nickel, Zinc, pH, Harness (CaCO3), Bromine, Free Chlorine, Total Residual Chlorine. Results provided in 1 14 09 2008 Annual HAL SRE Report. Data derived from graphs (approximate).

- HAL identified the metal removal efficiencies by volume, copper was approximately 90% removal, Ni 67% removal and Zn 54% "removal: by AWTS system.
- HAL identified in preseason 2009 that water conservation in general would create less discharge volumes and less environmental loading of the metals.
- In 2009 HAL started the Laundry water investigation on Westerdam and Ryndam. The investigation includes a theoretical approach to calculate potential metal loads from laundry operations.
- After the Ozone treatment system was installed (Arti clean equipment) additional sampling was performed. See Table H3E.

Table H3B
HAL Fleet selected Vessels
2008 Source Sampling

Vessel	Source	Location	Results* ug/L				Remarks
			NH4 mg/L	Cu	Ni	Zn	
Statendam	Evaporator^	Chlorination point	0.21	77	14	15	Zenon
8 25 08	Tech. water	Tech. water pump	0.25	320	15	64	
1993	Water Distr.	Potable stores	0	85	7.1	59	
	Galley GW	Galley drain tank	0.31	140	20	180	
	Laundry GW	Laundry drain tank	0.95	330	25	170	pH 10.57
	Acco. GW	AC room collection tk	1.3	240	27	360	
	Com. pre-treat WW	Buffer Feed tk bioreactor	69	150	20	270	Total Hardness 250
Zaandam	Evaporator	Chlorination point	0.1	140	120	60	Zenon
8 27 08	Tech. water	Tech. water pump	0.1	92	13	34	
2000	Water Distr.	Potable stores	0.057	160	17	76	
	Galley GW	Galley drain tank	0	98	11	13	
	Laundry GW	Laundry drain tank	0	2.2	18	13	pH 6.27
	Acco. GW	AC room collection tk	1	90.3	16	55	
	Com. pre-treat WW	Buffer Feed tk bioreactor	85	19	78	30	Total Hardness 68
Westerdam	Evaporator	Chlorination point	n/a	0.97	0.76	8.1	Rochem
8 28 08	Tech. water	Tech. water pump	0.17	570	6.8	190	
2005	Water Distr.	Potable stores	0	76	5.6	76	
	Galley GW	Galley drain tank	0.46	3.7	0.65	13	
	Laundry GW	Laundry drain tank	0.36	590	2.4	13	pH 9.0
	Acco. GW	AC room collection tk	4.8	110	22	55	
	Com. pre-treat WW	Buffer Feed tk bioreactor	150	19	17	30	Total Hardness 100

Note: *Results obtained from Reported Graph/approximate.

^The sample flow from the Evaporators combined, separate samples per evaporator are not made.

Table H3C
Cu Laundry Water Samples 2009
Westerdam Ryndam

Vessel/sample date	2009 Results ug/L*			
	Laundry Supply	Laundry Drain Tk	Increment	Comments
copper Cu				
Westerdam				
6 17 09	120	240	120	
6 24 09	60	140	80	
7 8 09	60	125	65	
7 15 09	60	125	65	
8 5 09	110	160	50	
8 26 09	90	120	30	
9 2 09	210	290	80	
9 16 10	100	150	50	
Ryndam				
6 23 09	65	140	75	
6 30 09	50	95	45	
7 7 09	60	150	90	
7 21 09	60	365	305	
8 4 09	60	125	65	
8 11 09	48	105	57	
9 1 09	20	60	40	
9 8 09	70	140	70	

Note: *Results obtained from 2009 Reported Graph/approximate. Graph not clear/Data value interpretation may not correct. No raw sample data provided by HAL.

Table H3D
Ni Laundry Water Samples 2009
Westerdam Ryndam

Vessel/sample date	2009 Results ug/L*			
	Laundry Supply	Laundry Drain Tk	Increment	Comments
Nickel Ni				
Westerdam				
6 17 09	14	23	9	
6 24 09	6	8	2	
7 8 09	6	Missing data point	N/A	
7 15 09	4	9	5	
8 5 09	5	7.5	2.5	
8 26 09	5	5	0	
9 2 09	9	11	2	
9 16 10	4	7	3	
Ryndam				
6 23 09	20	26	5	
6 30 09	15	Missing data point	N/A	
7 7 09	10	15	5	
7 21 09	12.5	17.5	5	
8 4 09	12.5	19	6.5	
8 11 09	12.5	18	5.5	
9 1 09	13	17	4	
9 8 09	16	19	3	

Note: *Results obtained from 2009 Reported Graph/approximate. Graph not clear/Data value interpretation may not correct. No raw sample data provided by HAL.

Table H3E
Zn Laundry Water Samples 2009
Westerdam Ryndam

Vessel/sample date	2009 Results ug/L*			
	Laundry Supply	Laundry Drain Tk	Increment	Comments
Zinc Zn				
Westerdam				
6 17 09	240	260	30	
6 24 09	60	90	30	
7 8 09	50	70	20	
7 15 09	80	95	15	
8 5 09	60	90	30	
8 26 09	75	90	15	
9 2 09	100	180	80	
9 16 10	60	120	60	
Ryndam				
6 23 09	60	70	10	
6 30 09	40	110	70	
7 7 09	25	85	60	
7 21 09	85	260	175	
8 4 09	40	110	70	
8 11 09	40	150	110	
9 1 09	45	Missing Data Point	N/A	
9 8 09	75	200	125	

Note: *Results obtained from 2009 Reported Graph/approximate. Graph not clear/Data value interpretation may not correct. No raw sample data provided by HAL.

Table H3F
Laundry Water Samples 2009
Ryndam Ozonator

Vessel/sample date		2009 Results ug/L*			
		Laundry Supply	Laundry Drain Tk	Change	Comments
Ryndam					
12 27 09	Cu	2910	1480	-1480	
	Ni	948	34	-914	
	Zn	3700	246	-3454	
1 3 10	Cu	1180	1600	420	
	Ni	36	23	13	
	Zn	79	167	88	

Note:

- A component of technical water is water (condensate) from the AC units. Because the produced AC condensate/water is not "constant", the contingent of condensate water from AC in Technical water sample may not representative.
- Although this comment is not conclusive, the Vista Class vessel are equipped with evaporator units that contain titanium elements, this may be a reason that the metal sample results are relatively low.

- End of 2008 cruise season it appears that no strategic sourcing of water was done, nor segregation of bunker water source or "isolation" of potentially waste streams with high metal loads.
- HAL developed a model to compute "predicted values" of copper, nickel and zinc based on the average concentrations from the various sources. This model would be used in 2009 for strategic bunkering.
- However, in the 2009 season Ocean Ranger found little evidence that "strategic bunkering" was done (consistently) during the season. Although HAL in the 2009 end of season reporting included for some vessel "preferred water sources". After the August 2009 meeting (ADEC/HAL) it appear the vessel started more actively with "strategic bunkering. HAL identified that strategic bunkering was attempted, by the results were not conclusive, and provide for only 3 vessels of the fleet the 2009 potable water source/bunker locations (% volume) See Table H3A. Comparison to the 2008 fleet and "source patterns" could not always performed.
- In the 2009 data for 3 vessels the sources of on board made water did not include technical water, or change of operations or new selected ww holding regimes.
- HAL believes that this strategic bunkering is inconclusive, and does not provide a strong indication of metal load reduction.
- Bunker water comes in Port form different "tap points" (bunker circuits), the stragic sourcing did not identify which tap point in which port was used. See ACA Bunker sampling.
- Predictive metal values may a good tool, but it should be noted that the HAL vessels relatively bunker small amounts of potable water in Alaska. However, the predictive model predicted significant metal load reductions for the 2009 season (Cu, Ni, and Zn).
- HAL fleet used copper anodes (sacrificial) to reduce/to minimize marine growth on hull and seawater piping. This system releases "copper ions" to the ambient (intake) water of the evaporator. This may carried over in the evaporator to the distilled water, and may lead to increases of copper concentrations.
- Total Hardness of evaporator water is very soft (mg/L) < 17.1 Soft, 60-120 Medium Hard, > 250 Very Hard.
- Highest copper concentration is found in laundry waste water.

- Water reduction plan/strategy were started in 2009, to reduce metal loads. However it should be noted that earlier was identified that water conservation of the toilet flushes lead to the ammonia issues.
- Laundry water Investigation: Laundry Ozonator was meant to reduce water, Vendor verification response included that this equipment will reduce water consumption in Laundry, but it will not remove metals, or ammonia. HAL identified that the laundry did contribute to the overall mass of metal loading. In 2009 Ozonator was installed.
- In the laundry study was included the assumption made that 22% of the potable water use is in the laundry operations. Limited sampling appears was done in 2009 on the Westerdam and Ryndam. See Table H3B, C and D. Also projected calculations (assumptions) were made with regard to the metal load. Also HAL identified the effects of a copper penny in the laundry (residue clothing) and the effects on metal loads caused by incidental source of contamination.
- No actions appear to be taken to reduce or specifically to identify the metal sources for the laundry operations.

3.2.2. Chemical Use/Process Evaluation

- Identification of cleaning products, rodenticides, or other industrial products that may contribute to metal and ammonia loads in waste water;
- Evaluation include also chlorine or other halogenated products that may accelerate pipe corrosion;
- Reviewing Hotel procedures, replacing chemicals and identification of other activities that contribute to the source of ammonia.

Actions included in SRE

- Chemical substitution for products identified as contributing to contaminants of concern or leaching potential in the drainage systems
- Substitution of non-chemical methods for processes that involve chemicals.
- Hotel, Technical Department, Steiner products (spa pool) and all combined use of chemical reviewed and assessed.
- For example Solid Power dishwashing agent contained very small amount of Zn, Oasis 115XP floor cleaner contained small amounts of

Ammonia. Also was Gemstar Laser floor cleaners, contained zinc in solid form.

- Unitor chemicals used in nautical and engineering department are only three chemicals that can enter the WW system; the de-foamer concentrate, and potable water stabilizer
- Hepburn products are biodegradable. Hepburn reports no heavy metals/ammonia in their products.

Note:

- HAL did not specific identify the use of chemicals in the evaporator systems and if these chemicals affect the effluent quality.
- Most chemical were listed and inventoried and spec sheets obtained from the vendors.
- Unitor chemicals included the defoamer and potable water stabilizer.
- De-scaler is used to clean piping. BW 100 de-scalers are used, on all HAL fleet vessels. Special de-scaler pumps are used to dosage he chemicals in the drain system. Average use per vessel was 28.5 liter per day. Over dosage affects metal drain piping internal coating. De-scaler is a proprietary hydroxyacetic acid, with undiluted pH of 1.5.
- Product substitution and Implementation: HAL believes that chemicals on board are not a significant contributor of the pollutant s of concern. The impacts of the products are small, and even the total elimination of these products would, according HAL not provide a measurable improvement.
- HAL believes that the next best effort will be treatment based (to reduce Ammonia and metal loads) rather than focusing in the direction of products substitution.
- HAL completed this project, and found that Spa/Salon products do not contribute to the ammonia load (Steiner Products).

3.3. Treatment Technology Evaluation/Implementation

The HAL fleet has two types of AWTS plant in installed on board (See Table H2):

- Zenon system: Handles GW and BW in combination, the treatment process is as follows:
  - Collection Tanks, Pre-screening, biodegistion microbial digestion, ultra filtration for bacteria and suspended solids screening

    - "Zeeweed" membranes. UV treatment before overboard discharge. Zenon is a brand of the GE waste water group.

- Rochem system: Handles BW and GW in separate "sections", the treatment process is based on ultra filtration, and low pressure reverse osmosis technology;
    - Collection tanks, Bio Felt treatment plant (BTP) section consists of combined technology aerobic process of high density biomass with ultra filtration for BW treatment. Gray water filtration plant (GWFP) based on low pressure osmosis. Rochem is a brand of the Rochem Triton Waste water technology group.

Evaluation of Technologies

HAL included technologies descriptions for removal of ammonia and refer to EPA reporting (EPA Draft Assessment). The metal removal technologies are identified, the ion exchange and reverse osmosis technology.

- Research project and consultation with vendors was identified;
- Treatment technology evaluation, HAL was to start with dedicated committee to look in more detail in available technologies. Also the evaluated technologies, are evaluated in the committee against set criteria, e.g. safety, footprint, costs, approval etc.
- Pilot Study I: Was to be conducted; and based on the results obtained, in 2010 commissioning was scheduled prior discharging 2010. HAL intend to do a pilot project on one of their vessels, with regard to reduce the ammonia levels. The idea is to look in conversion (use) of existing tank (double bottom), to add more tank storage, and allow for more residence time of waste water, allowing to support better the nitrification process to remove mass of ammonia. Installation of a pilot treatment plant would be necessary.
- Pilot Study II: This study is "transferred" to another vessel in the Carnival Cruise Line Fleet, the Golden Princess. Termination of Pilot Project on HAL vessels. The new project is called "Ammonia Reduction Project".
- Nitrification enhancement: HAL is investigating if waste water additives can be used to enhance nitrification in the existing waste water treatment process, and thus reducing ammonia loads. This additive is a bacteria.
- End of 2009 season Pilot study report include the actions taken on the Golden Princess. Also was identified the "extra tankage" need for

this project may not available on the HAL vessels because they are much smaller than the Golden Princess (Princess Fleet) vessels.

- Sampling at the end of 2009 for Ammonia showed poor sample results. The nitrification enhancement appears not to work (yet).

Current WW information 2008 HAL Fleet

Gray and Black water mixing ratios were included Table 4 list the GW and BW mixing ratios, as discharged by the vessels.

Table H4
GW BW volumes in discharge
HAL Fleet 2008

Vessel	BW effluent %	GW effluent %	Remarks
Oosterdam	38	62	Rochem AWTS/No discharge in AK in 2008
Westerdam	38	62	Rochem AWTS/Limited volume discharge 2008
Ryndam	8	92	Zenon AWTS
Statendam	8	92	Zenon AWTS
Veendam	8	92	Zenon AWTS
Volendam	7	93	Zenon AWTS
Zaandam	7	93	Zenon AWTS

Actions included in SRE

- HAL had discussions with their vendors, Rochem, Zenon, and GLV Inc.
- Vendor's discussions are summarized and "generic technical solutions" were included; also the technical limitations are identified. No technical conclusions. However it was identified that bench testing/pilot on board testing would be necessary.
- Ammonia nitrate/nitrification would require significant conversions of existing tanks.
- HAL has convened a Technical Evaluation Committee and commenced in a more detailed evaluation of potential treatment technologies during the period of January through April 2009.
- HAL identified Electro-Dialysis Reversal (EDR) for metal treatment. Included dimensions of units and the workings of the units.

Note:

  - Non treated waste flows or segregated waste water flows/volumes prior discharge are not included (if applicable). BW production per pax appears higher on vessels with Rochem systems than other AWTS systems. See Table H5.

- Rochem AWTS system Oosterdam non discharge reasons not identified;
- Rochem AWTS system Westerdam limited discharge volume not identified in 2008 (reasons unknown).
- BW represents a significant smaller volume compared to the GW waste streams.
- HAL fleet BW generation range (day) in the 40 –100 tons range. GW generation (day) in the 450 – 650 tons range. (approximate);
- Ammonia performance (increase) was according to HAL reporting contributed to by reduced oxygenation due to clogged air injectors (e.g. Westerdam) "greased up";
- HAL could not provide dimensions of the "extra tank" to support the nitrification process better.
- Electro-Dialysis Reversal Process (EDR) description did not include detailed specifics, HAL referred to web site to obtain details of this system. Requests for drawings of the system (detailed information) were deemed premature. HAL's Technical Evaluation Committee appears to look in the matter.
- HAL decides to terminate their own AWTS specific pilot study. In lieu of the specific pilot study for their specific AWTS plants (Rochem/Zenon); HAL hoped to use the "lessons learned" from the Golden Princess (Hamworthy AWTS system) pilot project.
- Further reporting on the progress of the Pilot Study is included in the Princess Cruise Line "Golden Princess" pilot study. Details of the pilot study and the correlation to the HAL vessels was requested. HAL later on identified that operational fluctuations of the GW BW ratio, and sludge retention time were factors of ammonia load on the Golden Princess Study. However, it was not identified how these parameters correlated or "apply" to the HAL vessels/operations.
- Using Nitrification enhancement additives (bacteria) requires still "optimum" process conditions to support the nitrification process. They are added in the bio-digester. The bacteria do not "convert" ammonia, but consume it a nutrient. This product is developed by R&D Supply and R&D Supply visited the Zaandam. Dissolved Oxygen, pH Temperature are parameters that affect the effectiveness of the enhancer in the process.

Sample results at the need of 2009 (12/27/09) for ammonia showed that the sample before the additive (bacteria) was 7.5 mg/L and after the enhancement (additive/ bacteria) 34.5 mg/L. This was a result that HAL did not expect, and it shows that other process/operational factors are affecting the nitrification process negatively.

Table H5
BW Generation per HAL Fleet/other vessels
Vessel per VSSP - NOI

Company	Vessel	Pax	Crew	BW VSSP m3/day	BW generation per person /day gal
HAL	Oosterdam	1848	800	100	9.98
HAL	Westerdam	1916	825	100	9.64
HAL	Ryndam	1260	580	40	5.74
HAL	Statendam	1266	588	40	5.70
HAL	Veendam	1258	588	40	5.72
HAL	Volendam	1440	647	40	5.06
HAL	Zaandam	1140	647	40	5.91
Carnival	Carnival Spirit	2125	934	90	7.77
Celebrity	Mercury	1870	909	120	11.41

Ammonia Reduction Project [Pilot Study II Golden Princess]

HAL and Princess are working collaboratively with Hamworthy (AWTS Vendor) to evaluate ammonia reduction on the Golden Princess. So far base line information on the quality of the influent is gathered.

HAL identified that the Hamworthy process has has the same basic approach of waste water treatment as the Zenon and Rochem systems.

Note:

- Although that all AWTS waste water systems have similar process elements, some systems do the same, but the process is different.

4. NORWEGIAN CRUISE LINE SRE OVERVIEW

Table N1 provides an overview of the by the Norwegian Cruise Line (NCL) provided documentation for the 2008 and 2009 cruise season. Please note this include a global overview of the documentation.

Table N1
2008 2009 Season
SRE NCL Documentation Global Overview

Cruise Line	Reports Year 2008	Reports Year 2009	ADEC Questions Comments	Cruise Line Response	ADEC Summary
NCL	Yes S/6/20/08 Final^		-	-	Yes ADEC NCL Review SRE 6/20/08
	Yes A 1/14/09*		Yes 1/21/09	Yes L 2/12/09	-
		-	Yes L 3/13/09	Yes L 4/30/09	-
		Yes A 4/30/09	-	-	-
		Yes A 1/15/10*	-	-	Yes ADEC NCL Review SRE 1/15/10

Note: *=Date of report; A=Annual Report; S=Start SRE application; D=Document; and PR=Pre Season Report ^=Confidential Version

4.1. Global Elements Summary of the Submitted SRE Report 2008 2009:

The main groups of SRE items for NCL are listed below in Table N2; group items were used by most, if not all, operators in their SRE related reporting in 2008 and 2009. CCL provided brief SRE reporting. NCL provided brief and to the point SRE reporting. NCL identified that some items, in particular the AWTS process modifications, were reported under confidential status. The ADEC review included these items but does not identify them in detail.

Table N2
2008 2009 Season
Reporting SRE NCL Main Groups

Main Group	
	Description concise
I. Influent Source Reduction	[waste water flows to AWTS System]
a. Source Water Evaluation	[sources contributing]
b. Chemical Use/Process Evaluation	[use of Hotel Engine room Chemicals]
c. Water Supply Evaluation	[evaporator/Bunker water/Treatment]
II. Treatment Technology Evaluation/Implementation	[new/improved technology]
III. AWTS operations/optimalization/data	[AWTS specific]

4.1.1. General Vessel Operations

All operations described are in relation to the SRE plans.

4.1.2. Vessel SRE Items Reports Results

This section includes a very concise description of the vessel operations assessed per fleet/cruise line.

Table 1 provides an overview of the cruise lines that provided SRE reports and performed actions on board; below is for each cruise line per season a concise description given of the reported SRE items and which specific vessel information was obtained.

Table N3
2008/2009 NCL Fleet Status

2008 2009 Season:	Vessel Name	Year Delivery	AWTS Type/Units Cap m3	2008 Discharge Status	2009 Discharge Status
	Norwegian Pearl	2006	Scanship/1780	Yes	Yes
	Norwegian Star	2001	Scanship/1400	Yes	Yes
	Norwegian Sun	2001	Scanship/1440	Yes	Yes
Notes: ND=Non Discharger D=Discharger					

4.2. Influent Source Reduction

4.2.1. Source water evaluation

Three main groups:

- Bunkered water from Shore facilities;
- Evaporator water produced on board; and
- Technical water produced on board.

At the end of the 2008 season, NCL undertook a study of dissolved metal content at various locations throughout the Alaskan fleet vessels. A summary of the results are in Table N4. Note that NCL provided a "description"/narrative of the sample results; detailed listing of location/values were not identified.

GW and BW are separately collected and from these dedicated tanks mixed in the GW/BW tank, this was the tank were the sample was taken.

It should be noted that there are some influences onboard that increase the metal loads, and in particular, the copper load. The Norwegian Sun is plumbed primarily with poly-butylenes potable water piping, but had still marginally higher copper levels than a ship with copper piping (Norwegian Star). NCL identified that the use of metallic parts in the poly butylenes piping system is minimal.

Sampling of bunker quality is included in the ACA report. The results of the bunker water source evaluation are discussed separately.

NCL reviewed the tank coating and believes that tank coatings do not contribute to metals in tank water. On the Norwegian Star, NCL switched to Novalac epoxy coating, which is more resistant to the aggressive nature of waste water.

Strategic sourcing of bunkered water was not identified in the initial SRE.

Notes:

- Vessels have Reverse Osmosis fresh potable drinking water equipment;
- Evaporator appears to contribute to elevated copper levels.
- Chemicals are used in the evaporator system. It appears that these chemicals are used in the overboard circuit from the evaporator, but it is not identified if the chemicals are "carried over" into the potable water circuit. Also not identified was whether or not chemicals are used in the evaporator on the "distilled water side" (potable water circuit).
- Piping materials from the "shore connections" (bunker water) to the potable water storage tanks on board of the vessel, the "inter piping" between storage tanks, and valves, fittings and pumps materials were not identified in the descriptions.
- NCL did not identify how potable water is treated from the bunkered source and the produced water (evaporator/RO), in order, if applicable, to neutralize acidity, restore necessary salts and hardness to distilled water to make it palatable, to prevent the formation of sediments, and to inhibit corrosion.
- Tank coatings of the potable water systems storage are not identified.
- Optimization of bunkered versus evaporated water sourcing/evaluation, sampling was done on Star Princess but optimalization/balancing potable water evaporator water appears not done or included in the SRE.
- ADEC was not aware of any communications or progress made by the ACA regarding the review of piping/systems on the port facilities. See also ACA potable water study (overview in Section 9).

Table N4
NCL Alaskan Fleet Vessels
2008 Source sampling results
[Based on narrative only]

Vessel	Source	Location	Results* ug/L			Remarks
			Cu	Ni	Zn	
Norwegian Star						
[8/26/08]	Pot Water	Bunker line	1300	-	-	Narrative^
	Pot Water	Evaporator RO plant	No A"	-	-	Narrative
	Pot Water	Everywhere else	280	-	-	Narrative
	Pot Water	Galley	-	20	-	Narrative
	WW untreated	GW BW mixing Tk	-	-	160	Narrative
Norwegian Pearl						
[9/21/08]	Pot Water	Evaporator (no RO)	<40	-	-	Narrative
	WW untreated	GW BW mixing Tk	1300	1200	-	Narrative
Norwegian Sun						
[8/20/08]	Pot Water	Evaporator (no RO)	<100	-	-	Narrative
	WW untreated	Influent AWTS	310	-	-	Narrative

Note: - = no data/narrative provided. ^ = Mystery value; NCL no copper piping. " = No copper added.

Technical Water

- NCL did not identify the use/presence of technical water.

4.2.2. Chemical Use/Process Evaluation

Actions included in SRE

- Review of hotel procedures, and evaluation of pesticides and rodenticides used on board. Almost all the products are dry containers or traps. Only one product (Bio Gel) is used in the galley and bar floors to control insect infestations. Maximum usage is about 4 liter per month.
- A review chemicals used onboard was conducted, focusing on chemicals that may be introduced in the BW and GW waste water systems. Both Ecolab and Unitor products are used, though Unitor to a lesser extent, and only to clean waste water piping.
- NCL reported that all their Ecolab chemicals are on "alkaline basis" and do not contain metals or contribute to the metal loads. Gamazyne products are used as bio-organic cleaners (BTC and TDS); BTC is used to clean toilets.
- NCL does use (ether-alcohol based) defoamer in the Evac systems.
- Washing detergents will be evaluated as well. NCL is currently in the process of switching suppliers.
- In 2009, NCL switched to Swisher hygiene products. These products do not contain ammonia, copper, nickel or zinc, with the exception of a floor cleaner and glass striper. Each contain small amounts of ammonia and are used sparingly. Dishware washing and laundry products do not contain ammonia. copper dispensing tubes have been replaced with steel tubes.

- Zinc components are present in Zinc floor finishing products, but NCL believes that this product does not end up in the GW BW systems.

Notes:

- Product substitution and implementation of a new chemicals inventory was not included in the initial SRE.
- Use of piping de-scalers or other drain system chemicals are not identified.

4.3. Treatment Technology Evaluation/Implementation

NCL has a Scanship AWTS system on board. Their initial SRE reporting appears to focus in detail on the effluent performance and improvement of the Scanship systems with regard to ammonia.

NCL provided detailed technical information of their AWTS upgrade plans. Information was clear and concise. NCL was the only operator with a plan that included action plans and alternatives from the start of the project.

The NCL fleet has only one type of AWTS system, the Scanship system. Below is a description of the Scanship AWTS system provided:

1. Scanship System: The Scanship system as is installed (assessed 2008 before possible modifications), consists of 5 primary stages: Drum type pre-filters, a moving bed bioreactor (MBBR), and flotation units, polishing filter and UV units. Only the MBBR has the capability of removing the ammonia through nitrification. Dissolved metal removal (according the NCL report) may results from steps to reduce BOD which may aid in the removal of ammonia.

Evaluation

NCL had detailed discussions with Scanship, and it was indicated that some modifications on the Scanship systems are possible and may produce result to meet the standards. In order to reach this goal, the following modifications were necessary:

   - Retrofit the existing bio-reactors.
   - Change carrier elements in bio reactors.
   - Increase blower capacity on bio reactors to increase the rate of nitrification (dependant on an engineering analysis of air flow issues (pressure and venting considerations).
   - Alternatively, consider a pure oxygen generator system.

2. Install a polymer dosage system ahead of the pre-treatment filter in order to increase pretreatment BOD removal, thus making more bio-reactor volume available for nitrification.

3. Install a new high efficiency polishing filter after the flotation units.
4. If (1) and (2) do not achieve the desired results, install ammonia ion exchange filters for ammonia polishing. These filters are only capable of removing smaller amounts of ammonia and cannot be relied on if 1) and 2) do not work.

Technical Discussion AWTS System Actions [assessed 2008]:

Detailed AWTS modification information was provided by NCL.

At NCL's request, the proprietary information is removed and the initial report is marked *confidential.* A revised version has been prepared for public use.

- Bio-reactor retrofit. The present bioreactors are based on the Kaldness MBBR process and were not designed for nitrification. Biological processes are normally limited by DO (dissolved oxygen) and particularly apply for nitrification (oxidation of ammonia). Nitrification is an operation that is linearly related to dissolved oxygen and detention time. Providing more oxygen to the bioreactor and increasing the detention time will increase degradation of organic material and enhance nitrification. Adding extra blowers will increase the total biodegradable rate for both organic material and ammonia. The exact rate cannot be determined using the onboard bioreactors as their design does not allow for a full-scale test. However, their design does allow for nitrification by:
  - Changing residence time distribution. This will take some time, and the system has to be completely shut down before brought on line again.
  - Increasing the bio surface.
  - Increasing the amount of oxygen available for nitrification. Although the bioreactor, at present, is equipped with redundant blowers, they are likely insufficient to bring the dissolved oxygen level to the required levels. An oxygen generator may be an option but will require Class and USCG approval.

The nitrification process produces acid. If the water has sufficient alkalinity, this will be not a problem. Scanship shows that the water "has sufficient alkalinity", and the nitrification will reduce the alkalinity, and may not cause process issues, because the chemical use in the floatation section also lowers the alkalinity. The acid production during the nitrification can also cause a drop in the pH, and the pH will continue to drop with additional coagulant dosage. The worse case pH is 6.5. NCL will test this process.

Additional considerations

- Use of organic coagulant in lieu of the conventional coagulant. May raise pH, and reduce the coagulant used.
- Polymer addition to primary treatment step. This may increase the removal rate of the organic material and may some metals. Lowering the organic load to the bioreactors may make the system more suitable for the degradation of ammonia.
- Installation of a high efficiency polishing filter after floatation units. This will lower the organic load to the bio reactors and may make the system more capable for the degradation of ammonia. Reaching 20 mg NH4-N/L may be possible.
- Installation of an ammonium ion exchange filter to cut the top peak loads that cannot be removed in the bioreactors. Ammonia can be removed to very low levels through ion exchange by the use of zeolite clinoptilolite. The filter columns filed with clinoptilolite have to be regenerated about every week by the use of NaCl and NaOH. This system will work only if the steps above can reduce the ammonia levels to about 5 mg/L.
- The "additional" increased oxygen levels may create an "oxidation problem" on the used metals and will further increase metal load.
- After the R&D process was fine-tuned in 2008, they decided to install an Oxygen Generator in 2009.
- NCL has committed $700,000 to the upgrades, and plans to work on the improvements to the AWTS systems.
- Phase 1: Norwegian Pearl and Star work vessels. Work on the Norwegian Sun is on hold, waitng for an initial sample test (phase). Construction will start in the 2009 season.
- On the Norwegian Star, Phase 1 completed bioreactor work and replacement of bio-media. In addition, two continuous ammonia metering systems have been installed.
- A "Chem-Redux" system has been installed to reduce coagulant use.
- A new drum screen flushing system was installed that recycles treated water to flush out the first stage treatment unit.
- The remainder of Phase 1: the Oxygen unit is on order; installation may be done in the 2009 season (work crews, and possible distortion of the AWTS System).

NCL also identified potential space issues associated with space requirements on board. The Norwegian Sun and Star were vessels that were retrofitted with the Scanship systems; the Norwegian Pearl designed and build to accommodate the Scanship system.

Notes:

- Some vessels in the Alaska fleet with Zenon AWTS systems did have Oxygen Generators installed on their vessels.
- NCL did not include the BW GW ratios as they are currently used on board with relation to the Scanship systems.
- 2009 Ocean Ranger Reports included items that identified that NCL was actively making the "Scanship systems working"; it was also reported that OR (June 6, 2009) spoke with a Scanship engineer, and that the Oxygen piping had been run, so that Oxygen generators can be connected after the season.

Table N5
BW Generation per NCL Fleet/other vessel
Vessel per VSSP - NOI

Vessel	Pax	Crew	BW VSSP m3/day	BW generation person /day gal	AWTS System Cap m3/day
Norwegian Pearl	2376	1100	100/20*	6.2	1780
Norwegian Sun	2002	950	80	6.2	1440
Norwegian Star	2240	1100	60	3.9	1400
/ * = BW or Bio Sludge. Norwegian Sun VSSP 09 listed AWTS capacity 60 m3/hr.					

5. PRINCESS CRUISE LINE SRE OVERVIEW

Table P1 provides an overview of the by the Princess Cruise Line (PCL) provided documentation for the 2008 and 2009 cruise season. Please note this includes a global overview of the documentation.

Table P1
2008 2009 Season
SRE PCL Documentation Global Overview

Cruise Line	Reports Year 2008	Reports Year 2009	ADEC Questions Comments	Cruise Line Response	ADEC Summary
PCL	Yes S/8/19/08 Final		8/19/09 ADEC meeting suggestions	-	-
	Yes A/8/19/08 Revised		-	-	Yes ADEC PCL Review SRE 11/25/08
	Yes A 1/14/09*		Yes E 1/22/09	Yes LD 2 27 09	-
	-		Yes L 3/17/09	Yes E 3/18/09	-
		Yes A 4/30/09	-	-	-
			Yes L 9/9/09	Yes LD 11/2/09	-
		Yes A 11/2/09	-	-	-
		Yes A 1/15/10*	-	-	Yes ADEC PCL Review SRE 1/15/10

Note: *=Date of report; A=Annual Report; S=Start SRE application; D=Document; and PR=Pre Season Report

5.1. Global Elements Summary of the Submitted SRE Report 2008 2009

The main groups of SRE items for PCL are listed below in Table P2; group items were used by most, if not all, operators in their SRE related reporting in 2008 and 2009. PCL provided brief SRE reporting. Please note that not all operators adhered to a similar reporting style in their reports; this made the process of reviewing and comparing SRE reports more complex.

Table P2
2008 2009 Season
Reporting SRE PCL Main Groups

Main Group	
	Description concise
I. Influent Source Reduction	[waste water flows to AWTS System]
a. Source Water Evaluation	[sources contributing]
b. Chemical Use/Process Evaluation	[use of Hotel Engine room Chemicals]
c. Water Supply Evaluation	[evaporator/Bunker water/Treatment]
II. Treatment Technology Evaluation/Implementation	[new/improved technology]
III. AWTS operations/optimalization/data	[AWTS specific]

5.1.1. General Vessel Operations

Describes the water/bunkering etc. All operations described are in relation to the SRE plans.

5.1.2. Vessel SRE Items Reports Results

Table 1 provides an overview of the cruise line provided SRE reports and performed actions on board; below is a concise description given of the reported SRE items and which specific vessel information that was obtained.

Table P2
2008/2009 PCL Fleet Status

2008 2009 Season:	Vessel Name	Year Delivery	AWTS Type/Units Cap m3	2008 Discharge Status	2009 Discharge Status
	Coral	2002	Ham/2x320		
	Diamond	2004	Ham/3x320		
	Golden	2001	Ham/3x320		
	Island	2003	Ham/2x320		
	Pacific	1999	Ham/2x150	Not visiting 2008	
	Sapphire	2004	Ham/3x320		
	Sea	1998	Ham/2x226	Not visiting 2008	
	Star	2002	Ham/3x320		
	Sun	1995	Ham/3x240		Not visiting 2009
	Dawn	1997	Ham/3x240		Not visiting 2009
Notes: ND=Non Discharger D=Discharger HAM=Hamworthy – MBR AWTS					

5.2. Influent Source Reduction

5.2.1. Source water evaluation

Three main groups:

- Bunkered water from Shore facilities;
- Evaporator water produced on board; and
- Technical water produced on board.

PCL (category 2) focused their SRE on the metal loads from piping systems and evaporator systems on board their vessels.

PCL provided very detailed information regarding piping materials used for one vessel only. PCL vessels are not all built according to the same specifications and or at the same ship yard. Therefore each ship has different piping systems and different materials used in the piping system. PCL provided generic information (vessel/or vessel class was not specified) regarding their potable water systems onboard and at their water producing units (evaporators). Potentially the PCL fleet in Alaska could bunker water at the major cruise ports. Additionally, outside the state, San Francisco (CA), Seattle (WA), Victoria (BC) and Vancouver (BC) are ports where some of the PCL vessels “take on” bunker water.

PCL did not identify bunker water sourcing or the volumes of water produced onboard. PCL did identify that bunker water sampling would be undertaken, and provided sample data with regard to copper, nickel, and zinc concentrations at sample bunker water form Alaskan bunker water ports. The results from this sampling action are including in the ACA Bunker water sampling summary (see Section 9).

5.2.2. Evaporator systems/PCL fleet (typical) concise description:

PCL provided a Technical Operating Manual. It was not made clear if the methods, equipment and operations presented in the manual are applicable for the entire PCL Alaskan Fleet. Therefore this information should be treated as general information. Specifics per vessel class were not identified.

The Technical Operation Manual [Princess Cruises Source reduction Evaluation (SRE) Appendix N 8/19/2008 FINAL] provides typical information regarding the evaporator systems, distilled water transfer system, and potable water treatment. Evaporators are used on the PCL fleet to produce onboard potable water. Evaporators use cooling water and steam (heat) to produce water.

Notes on the PCL fleet (typical) provided descriptions of the evaporator potable water systems:

- Chemicals are used in the evaporator system. It appears that these chemicals are used in the overboard circuit from the evaporator, but it is not identified if the chemicals are “carried over” into the potable water circuit. It was also not clear if chemicals are used in the evaporator on the “distilled water side” (potable water circuit).
- Piping materials form the “shore connections” (bunker water) to the potable water storage tanks on board of the vessel, the “inter piping” between storage tanks, and valves, fittings and pumps materials were not identified in the description(s).

Evaporator/Bunker water treatment

- PCL identified that potable water from bunkered sources and produced water (evaporator) must be treated to neutralize acidity, restore necessary salts and hardness to distilled water to make it palatable, to prevent the formation of sediments, and to inhibit corrosion.
- PCL provided [Princess Cruises Source reduction Evaluation (SRE) Appendix L 8/19/2008 FINAL] a Piping Application Schedule for their Vessels built in

Japanese Shipyards (Mitsubishi). These are general examples and do not include other vessel built under different specifications and yards.

Actions included in SRE

- Sampling of bunker quality (ACA report). The results of this source evaluation are separately discussed. PCL did gather an additional set of samples from bunker ports.
- Strategic sourcing of bunkered water was not identified in initial SRE. Table P3 includes port information regarding the ports at which PCL vessels take on bunker water.
- Controlling the Langlier Index to achieve readings between -0.5 and +0.5 (balanced) to minimize pipe corrosion and corrosion on other system parts.
- The alternative to the Langlier Index control is US FDA approved polyphosphate corrosion inhibitors in the water system.
- In the pre season report of 2009, it was state that “the source Water evaluation/Shore Potable water testing” actions were completed.
- The 2009 Pre season Report included the following: “At this time Princess Cruises has not made any operational changes to its potable water sourcing verses producing it own distilled water onboard”. As member of the Alaska Cruise Association (ACA), efforts are being made to determine if ports which supply the potable water can study types of metals found in valves and piping materials used to supply the water to the ships. See Notes.
- A water conservation program was to be included in the 2009 season.
- In 2009, ADEC requested an overview of the water sourcing, and this is provided in Table P5. The bunkered water volume (%) ranges from 47% to 22%; the majority of the water is produced on board.
- PCL reported in 2009 that is has not been able to influence the characteristics of the potable water supplied by the various ports. PCL does not believe that it has much control over the potable water supplied form the various ports for reduction of the metals. PCL did not specify specific ports.

Notes:

  - Tank coatings of the potable water storage systems are not identified.
  - Piping materials form the “shore connections” (bunker water) to the potable water storage tanks, inter piping between storage tanks, valves, fittings and pumps materials were not identified in the description(s) reporting, except for the Japanese built vessels.

- Optimization of bunkered versus evaporated water sourcing and evaluation, sampling was done on Star Princess but optimalization/balancing potable water evaporator water appears to not have done or was not included in the SRE.
- The water balance was not obtained using the Langlier Index (and related actions) or it was not identified in the 2009 reporting. No reason was provided as to why this option was abandoned.
- Also, the Langlier Index control using polyphosphate was either not done or not identified in the 2009 reporting. No reason was provided as to why this option was abandoned.
- ADEC was not aware of any communications/progress made by the ACA regarding the review of piping/systems on the port facilities. See also ACA potable water study (overview in Section 9).

Table P3
2008 2009 PCL Fleet
Potential Potable Water Bunker Ports

Vessel	Ports								
	SF	SEA	VIC	VAN	KTN	JNU	SKG	WHT	KDK
Coral	-	-	-	x	x	x	x	x	-
Diamond	-	-	-	x	-	x	x	x	-
Golden	-	x	X	-	x	-	x	-	-
Island	-	-	-	-	x	x	x	x	-
Pacific	Not listed								
Sapphire	-	-	-	x	x	x	x	x	-
Sea	Not listed								
Star	-	x	x	-	x	x	X	-	-
Sun	x	-	x	-	x	x	-	-	-
Dawn	x	-	x	-	x	x	x	-	-
= No water bunkering x=Yes water bunkering No volumes/frequency identified									

Table P4
PCL Star Princess selected Vessel
2008 Source Sampling

Vessel	Source	Location	Results* ug/L			Remarks
			Cu	Ni	Zn	
Star Princess						
[6/17/08]	Potable Water	Pot Water Tk (8&9)	15.3	1.74	17.8	
		Tap Bridge Pantry 14	19.5	1.87	26.9	
		Cabin 10 FWD (hot)	52.3	8.27	33.5	
		Cabin 8 FWD STB (hot)	56.3	8.2	34.9	
		Cabin Deck 11 Mid ship	44.7	2.21	33.7	
		Cabin Deck 4 Port	41.6	1.85	40.0	
		Tap Crew Galley 5 Aft (hot)	26.3	10.4	25.2	
[6/18/08]	Treated WW	Des. OB Dis Sample Port	59.2	13.6	123	
	WW	Alt. OB Dis Sample Port	116	258	183	
	BW influent	Influent MBR BW Evac 4	17	8.58	115	
	GW influent	Influent MBR GW buffer Tk	22.5	7.64	94.6	
	Potable Water	Pot Water Tk (11&12)	17.6	1.48	18	
[6/20/08]	Evaporator 1		49.7	3.13	15.4	
	Evaporator 3		42.5	1.04	51.8	
[6/23/08]	Evaporator 2		50.3	1	28.1	
[6/25/08]	Treated WW	Des. OB Dis Sample Port	55.5	15.7	119	

Note: ^The sample flow from the Evaporators combined, separate samples per evaporator are not made.

Table P4A
Golden Princess Evap Sample 2009

Vessel	Source	Location	Results* ug/L			Remarks
			Cu	Ni	Zn	
Golden Princess						
[6/7/09]	Evaporators		49	2.3	60	

Table P5
PCL Water Sources Volumes %
Alaska Fleet

Vessel	Evaporator Water %	Bunkered Water %	Comments
Coral	72	28	
Diamond	53	47	
Golden	70	30	
Island	71	29	
Pacific	65	35	
Sapphire	53	47	
Sea	78	22	
Star	68	32	
Sun	Not visiting in 2009		
Dawn	Not visiting in 2009		

Technical Water

- PCL did not identify the use or presence of technical water.

5.2.3. Chemical Use/Process Evaluation

- Reviewing hotel procedures, replacing chemicals and identification of other activities that contribute to the source of ammonia.

Actions included in SRE

PCL include in the summary of the initial SRE that “Category 3” contained information regarding the “chemical use/“other potential contributors”. However, detailed information was not included. In the 2008 annual report, it was announced that Hepburn biological toilet cleaners were used as an alternative. In 2009, a cleaning product evaluation program was reported, which required that any new chemical products used will be reviewed for the presence of ammonia, copper, nickel and zinc. This process was to continue indefinitely.

Notes:

- Product substitution and implementation of new chemicals inventory was not included in initial SRE.
- Use of piping de-scalers or other drain system chemicals are not identified.

5.3. Treatment Technology Evaluation/Implementation

The PCL fleet has one type of AWTS plant installed onboard (See Table P2):

- Hamworhty system: Handles GW and BW in combination. The treatment process is as follows:
  - The waste water BW and GW is treated by MBR1, MBR2, and MBR3. There are three AWTS units which are each treating a “part” of the waste water volume. BW is delivered to the EVAC tanks to the MBR’s, GW is delivered from GW collection tanks and then from there to one or two MBR’s buffer tanks. The buffer tanks provide some aerobic aeration through usage of blowers. BW and GW are mixed in common line to the MBRs. The Hamworthy has an MBR 1st stage screen press water link which filters papers and other screening out of the feed. The screenings are bagged and incinerated at sea. The feed flows in the 1st stage of the bioreactor which operates as an aerobic biological treatment system. This feed enters into a high strength biomass within which there is a diverse microbial ecology that breaks down the BW and GW. Byproducts are CO_2 and water. Water passes through the membrane, while CO_2 is vented to the atmosphere. This air supply to the biomass through fine air bubble diffusers also lowers the chemical oxygen demand (COD) of the waste.

From the first stage MBR, further filtering is completed in special Russell Type Bag Filters. Further solids are then redirected back to the screen press water link, and filtrate is pumped to the second stage of the bioreactor for further aeration. The second stage of the MBR is then pumped down via cross flow pumps which deliver feed to the membrane modules. Finally, effluent is pumped to the permeate tank and circulated through an UV filter, before being discharged overboard.

- Note: GW from the galleys and laundry are not treated in this way. Instead, GW is stored in double bottom tanks for discharge outside Alaska waters or at Juneau Dock to a shore facility.

Hamworthy Ammonia Performance Particulars/Technical Background MBR's

The Hamworthy systems were initially designed to remove BOD (carbon compounds) by a group of bacteria that grows quickly and reproduce quickly. These bacteria use O_2, consume BOD as food, and produce CO_2. During this process, they also consumes small portions of ammonia.

Another group of bacteria, the nitrifiers, grow slowly and reproduce slowly. The nitrifiers also breathe O_2, consume ammonia as food, and produce nitrate (NO_3); this process is called biological nitrification. Unlike BOD removal, nitrification generates acidity that consumes alkalinity, and thus lowers the pH.

Nitrifiers and BOD removal will compete. Because the nitrifiers grow slowly, a bioreactor that is de-sludged less often will help to retain more nitrifiers. A bioreactor that receives more BOD will grow more BOD removal bacteria, and a reactor that receives more ammonia will grow more nitrifiers. The nitrifiers are more sensitive to toxicity, temperature shocks, and oxygen content. Process conditions that are "favorable" for BOD are not favorable for the nitrifiers.

If the MBR is operated as designed, it allows the fast growing BOD bacteria to dominate the reactor because plenty of food (carbon) is available. To maintain a stable Mixed Liquor Suspended Solids (MLSS), sludge must be removed at a certain rate.

When the MBR receives too much or too little BOD loading than designed, this will result in a lower de-sludge rate (older sludge age in system), and nitrification may start at limited scale; this is called partial nitrification because the process is uncontrolled and unstable.

Some of the BOD removal process bacteria can use nitrate . These bacteria are called de-nitrifiers. The de-nitrifiers 'breathe" in nitrate and consume BOD, and produce nitrogen gas (N_2) this process is called biological denitrification. This process is very important because it produces alkalinity to neutralize the pH.

Specific Action Plans

- Dedicated action plans for vessels with different pH levels.
  - Plans include increase of MBR capacity by increasing GW feed water (to 80% of rated capacity)
  - Increase desludge frequency
  - Work with Hamworthy for follow up.
- Dedicated action plans for vessels with high Ammonia (>80 mg/L)
  - GW dilution factor
  - Increase de sludge frequency
  - Work with Hamworthy for follow up.
- Initial SRE includes plans for metal removal. The following plans and evaluations of other available technologies are included:
  - Carbon filter review
  - Controlling the Langlier Index to achieve readings between -0.5 and +0.5 (balanced) to minimize pipe corrosion and corrosion on other system parts.
  - Alternative to Langlier Index control is US FDA approved polyphosphate corrosion inhibitors in the water system.
  - Completion of the evaluation of the "Tischler/Kocurek Report April 2009"

Actions included in SRE

- PCL performed initial AWTS system evaluations and decided that Bio Care products to pre-treat waste water would help to improve the effluent performance.
- The Bio Care product uses the huge surface area in the waste water piping to create a vast bioreactor through the ship, effectively pre-treating all organic waste streams in situ, prior to further treatment in the vessel AWTS systems. The Hepburn products are supposed to biodegrade the waste water by reducing BOD and the TSS.
- The Bio Care products reduce the loading of the AWTS (MBR section) loading, and keep the BW piping system free of ammonia magnesium phosphates (scale).
- PCL is evaluating Bio Ammo-100 (Ammo), which is a liquid formulation of Nitrosomonas used to convert ammonia to nitrate, and Nitrobacter that

convert the nitrite to nitrate. This product is designed to remove the ammonia quickly in the aerobic biological treatment process.

- PCL stated that *"Hamworthy has also stated that the MBR(s) original configuration was not originally designed to achieve or sustain nitrification process".*
- PCL used the following Hepburn Bio Care products: WC dosage in WC toilets; ET dosage into mixing tanks; Nutrient dosage in MRS(s), Foam fighter dosage in EVAC tanks; Ammo 1000 dosage in Aeration Chamber.
- PCL provided product sheets and indentified that these products will continue to be used and evaluated to determine if any improvement has been achieved from sample results. A firm time line of the use (to discontinuation) was not set.
- PCL included an overview of the AWTS process issues, like pH, metals, and ammonia. These items are summarized in Table P6.
- Exhibit 4 Golden Princess included the verbiage "confidential"; PCL removed this verbiage and revised the document.
- Exhibit 4 included an Ammonia Removal trial on the Golden Princess.
- PCL has selected the Golden Princess to do a pilot study. This study will be done in two phases and started in 2009:
  - This pilot project was also used as "reference pilot project for the HAL"
  - MBR 3 is used and the small stage (first) of the MBR is converted to the Anoxic Tank, where denitrification process occurs. The large second stage bioreactor will continue to serve as an aerobic tank to support the nitrification process. MBR 3 is chosen because it is close to TK 5. TK 5 will be used as mixing balance tank. TK 5 is chosen because it was a redundant tank close to MBR 3. ISF is inter-stage filter and from this filter the tank will receive the feed.
  - Level controls (DP sensors) are installed to control and monitor tank level.
  - Phase 1: Was to understand more about the onboard process of the Ammonia issues. It also included characterization of the BW and GW streams. Hamworthy did onboard studies, and used onboard laboratories; flow rates and volumes were measured, installation of an on line ammonia meter and Total Oxidized Nitrogen (TON) meter was conducted.
      - Conclusions were as follows: BW from Toilets Evac system, high levels of Ammonia (100 mg/L). Note in reporting was also a maximum Ammonia level reported, however this maximum level

    - was not originated from this test, or related to the Golden Princess trial.
    - Sanitary GW and Laundry GW very low levels ammonia.
    - In the AWTS system, inclusion of GW treatment provides effectively dilutions of black water ammonia load.
    - Hamworthy Appendix A and B Methodology (attachment 1) include a detailed set out of the Phase 1 project, and include BW and GW characteristics.

- The Annual Report of 2009 (11/2/09) identified that the Phase I trial was completed, and that de-nitrification and nitrification processes are now occurring in the system (although unstable). Hamworthy believes that process improvements are underway. Hamworthy provided additional information (Presentation); see Attachment 4. A conclusion regarding final actions to take to achieve improved ammonia performance with Hamworthy systems was not clearly identified. However, some improvements and ideas were suggested:
  - Nitrification was not improved further by:
    - Lower treatment capacity; or
    - Higher DO
  - The Suggestions by Hamworthy were to:
    - Separate treatment dedicated MBR for only BW (e.g. MBR No. 3); and
    - Increase GW/BW ratio to 3:1
  - There were no changes in equipment or operations made to other PCL vessels as a result of the information that PCL learned on the "Golden Princess", primarily because trials were inconclusive. See Notes.
  - PCL concluded in the 2009 annual report that the fluctuation of ammonia loading to MBR 3 is very significant and difficult to stabilize. The trial de-nitrification efficiency deteriorated, possibly due to a defective blower. Maintenance work was done to correct the blocking of an anoxic zone mixing pipe, thus shutting down MBR 3. This allowed the start up process to be observed more closely (e. g seeding from other MBR).
  - Table P6 include an overview of the results/recommendations by Hamworthy.

Table P6
Hamworthy PCL findings recommendations 2009
Golden Princess Trail

Recommendations Hamworthy	
Both the anoxic and swing zone shall remain anoxic	
Increase and stabilize the DO to 2 mg/L in the aerobic reactor (stage 2 reactor)	
Reduce MBR feed to 90m3 /d	Not clear of notation/PCL appear not always using all MBR units (stand by)
Maintain BW GW mixing ratio 2:1	Earlier Hamworthy recommendation appears identify ratio 1:3?
Extend sludge age to 40 days –by de sludge 3% daily	

Notes:

- All the Hamworthy systems onboard are "modules/units", depending on installation 2 MRS or 3 MBR units.
- PCL did include the BW GW ratios as they are currently used onboard with relation to the Hamworthy systems.
- Details regarding dosages and methods, monitoring etc., was in identified in detail indentified PCL (Appendix K), but instruction, monitoring, etc., of the actions was not included.
- All AWTS waste water systems do have similar process elements. Some systems have similar results, though the process to achieve the results is different.
- It should be noted that the "Seven Seas Mariner" Hamworthy AWTS system exhibits relatively better ammonia effluent performance than the Hamworthy AWTS systems installed on PCL vessels.
- One would expect that Hamworthy/PCL would investigate further how other vessels in the Alaska trade that are equipped with Hamworthy systems achieved their relatively better ammonia performance. This was not proposed or included in the PCL/Hamworthy documentation.

Table P7
BW Generation per PCL Fleet/other vessel
Vessel per VSSP - NOI

Vessel	Pax	Crew	BW VSSP m3/day	BW generation person /day gal	AWTS System Cap m3/day
Coral	2400	900	200	16	Hamworthy See Capacity Table P2
Diamond	2670	1238	220	14.9	
Golden	2600	1060	240	17.3	
Island	2400	900	200	16	
Pacific	676	373	28	7.05	
Sapphire	2670	1238	220	14.87	
Sea	2270	910	80	6.65	
Star	2600	1150	240	16.9	
Sun	1950	870	80	7.5	
Dawn	1950	900	80	6.6	
Seven Seas Mariner	769	431	17	3.97	Hamworthy 2x180

Table P8
Hamworthy Performance Issues
PCL Fleet 2008 2009

Princess Alaskan Fleet	Issue	Plan
All vessels Hamworthy AWTS	Low pH	Process adjustments to be made i.e. reduce aeration/ships that have low pH (<6.5)
	Increase Ammonia	Ongoing trial with Hepburn Bio Care Products/Hamworhty trial for 2008 removal tests
	Increased Metals	Discuss potential solutions experts

6. ROYAL CARIBBEAN CRUISES LTD. & CELEBRITY CRUISE LINE SRE OVERVIEW

Table R1 provides an overview of the by the Royal Caribbean Cruises LTD./Celebrity Cruise Line (RCL) provided documentation for the 2008 and 2009 cruise season. Please note this is a global overview of the documentation.

Table R1
2008 2009 Season
SRE RCL Documentation Global Overview

Cruise Line	Reports Year 2008	Reports Year 2009	ADEC Questions Comments	Cruise Line Response	ADEC Summary
RCL	Yes S 4/28/08 Final		7/28/08	8/19/08	-
	Yes A 8/19/08		-	-	Yes ADEC RCL Review SRE update 8 19 08
	Yes A 1/14/09*		1/27/09	2/16/09	-
			2/3/09	RCL No/# 2/4/09	-
			3/13/09	-	-
		Yes A 1/15/10*	-	-	Yes ADEC RCL Review SRE 1/15/10

Note: *=Date of report; A=Annual Report; S=Start SRE application; D=Document; and PR=Pre Season Report, #=RCL could not respond on specific potable water questions, referral made to ACA

6.1. Global Elements Summary of the Submitted SRE Report 2008 2009:

The main groups of SRE items for RCL are listed below in Table R2; group items were used by most, if not all, operators in their SRE related reporting in 2008 and 2009. RCL provided brief SRE reporting and used the same reporting item format as the Holland America Line (HAL). Additionally, some of the initial SRE documentation included “Holland America Line” in the footer.

In 2009, RCL reported that all RCL vessels would provide SRE reporting, except for Serenade of the Seas, which was redeployed and did not visit Alaska in the 2009 season.

Table R2
2008 2009 Season
Reporting SRE RCL Main Groups

Main Group	
	Description concise
I. Influent Source Reduction	[waste water flows to AWTS System]
a. Source Water Evaluation	[sources contributing]
b. Chemical Use/Process Evaluation	[use of Hotel Engine room Chemicals]
c. Water Supply Evaluation	[evaporator/Bunker water/Treatment]
II. Treatment Technology Evaluation/Implementation	[new/improved technology]
III. AWTS operations/optimalization/data	[AWTS specific]

6.1.1. General Vessel Operations

All operations described are in relation to the SRE plans.

6.1.2. Vessel SRE Items Reports Results

Table 1 provides an overview of the cruise line provided SRE reports and performed actions on board; below is a concise description given of the reported SRE items and which specific vessel information that was obtained.

Table R3
2008/2009 RCL Fleet Status*

	Vessel Name	Year Delivery	AWTS Type/Units Cap m3	2008 Discharge Status	2009 Discharge Status
	Celebrity Infinity *	2001	Zenon	ND	ND
	Celebrity Millennium*	2001	Hydroxyl	ND [only discharged to sample for a study]	ND
	Serenade of the Seas*	2003	Scanship	ND	Yes Discharger (D)
	Radiance of the Seas*	2001	Hydroxyl	ND	ND
	Rhapsody of the Seas*	1997	Navalis [under construction]	ND	ND
Notes: ND=Non Discharger D=Discharger *=Vessels that participated in SRE Reporting per season.					

6.2. Influent Source Reduction

6.2.1. Source water evaluation

Three main groups:

- Bunkered water from Shore facilities;
- Evaporator water produced on board; and
- Technical water produced on board.

The Alaskan fleet is comprised of newer ships and does have a combination of metal and polybuten (plastic) piping. In engine rooms, mostly stainless steel piping is used. The vessels already removed significant parts of the metal piping (corrosion). Coating and tanks coating will be evaluated as well.

Sampling of bunker quality is included in the ACA report. The results of the bunker water source evaluation are discussed separately.

RCL did review the tank coating and believes that tank coatings are not contributors to the metals. Strategic sourcing of bunkered water was not identified in initial SRE.

RCL will try to control the corrosion through water treatment methods, replace piping with non metallic types, withhold discharges in Alaskan waters, or focus on end-of-pipe technologies. In 2009, on the Serenade of the Seas, Radiance of the Seas, Rhapsody of the Seas, Celebrity Millennium, and Celebrity Infinity, piping was renewed/replaced with non metallic piping (BW GW and potable water. If the replacement action was triggered by corrosion or other regular maintenance, the action was not identified. (See Notes).

In 2009, RCL confirmed that the industry potable water testing program (ACA study, see overview in Section 9) was completed. According to the results, there are bunkering ports where metals contained in the potable water are extremely high.

RCL identified that bunker strategies and dedicated tankage are still in development (RCL 2009 2 17 09).

Piping and device replacements after a few years of use is caused by synergistic causes such as soft water, chlorine as disinfectant, chlorine generation, dissimilar materials, and the varying chemistry of potable water found in ports of call and produced on board.

Replacement pipe is generally non metallic "George Fisher" or equivalent. Replacement generally took place when weepage or leakage is found (corrective maintenance). RCL also identified in their responses to ADEC questions that the "troubles" with piping are caused by low pH. The mandated (health) chlorination of potable water causes these problems.

Forecasts of water use/bunkered water strategies in 2009 could not be made by RCL because of:

1. Itinerary changes;
2. The Gas turbines have been replaced by diesel electric units. As a result, the heat to produce steam for the evaporators is now less, and more potable water from shore side facilities needed to be bunkered in 2009.
3. RCL will obtain much more specific information during the 2009 season. See Notes.

The Serenade of the Seas had all potable water risers changed during 2008. RCL also identified that the RCL vessels fully comply with RCL (internal) potable water treatment policy, minimizing soft water corrosion. See Notes.

Notes:

- Vessels have Reverse Osmosis fresh potable drinking water equipment.
- Chemicals are most likely used in the evaporator system. It appears that these chemicals are used in the overboard circuit from the evaporator, but it is not identified if the chemicals are "carried over" into the potable water circuit. Also, it was not identified if chemicals are used in the evaporator on the "distilled water side" (potable water circuit).
- Tank coatings of the potable water systems storage are not clearly identified.

- Optimization of bunkered versus evaporated water sourcing/evaluation, sampling appears not to be completed > Potable water balancing;- potable water use evaporator water use appears not done or included in the SRE.
- ADEC was not aware of any communications/progress made by the ACA regarding the review of piping/systems on the port facilities. See also ACA potable water study (overview in Section 9)
- Piping materials from the "shore connections" (bunker water) to the potable water storage tanks on board of the vessel, the "inter piping" between storage tanks, and valves, fittings and pumps materials were not identified in the description(s).
- RCL did not identify how potable water is treated from bunkered source and the produced water (evaporator/RO) in order, if applicable, to neutralize acidity, restore necessary salts and hardness to distilled water to make it palatable, to prevent the formation of sediments, and to inhibit corrosion.
- Piping replacement was per vessel and provided in percentage of "piping group" (function). RCL did not specifically identify root cause of the replacement actions. Also identified was that copper piping in some areas will be replaced in the future (Radiance of the Seas). RCL confirmed that on based on the condition of devices replacement will find place.
- Diesel engine cooling water has sufficient heat (due to good system design) to provide heat for evaporator systems.
- RCL did include project bunkered water volumes (estimated) but did not include the "balance" of produced water for 2009. Nor was total water use/consumption indentified.
- In 2009 end of season reporting, RCL initiated industry discussions regarding the feasibility of the bunker water infrastructure in ports.
- RCL did not include or explain in detail which technologies are used in the RCL's policy regarding potable water treatment.

Table R3
RCL Alaska Fleet Water
2008 2009 Operations [average]

Vessel	Evaporator Average day m3/day	RO water maker Cap day m3/day	Average condensate TG m3/day	Bunker Ports AK loading m3/week	Total Water Made m3/day	% Volume Bunker m3/day	Total Volume Water m3/day
Celebrity Infinity	Serck 760	Desal 0	10-15	N/a	775	0%	775
Celebrity Millennium	Serck 225	Desal 0	0	3670*	225	70%	750
Radiance of the Seas	Alfa 600	Desal 400	0	133 JNU 504 KTN 411 SKG 730 VAN	1,000	10%	1,150
Serenade of the Seas	Alfa Laval 650	Desal 350	0	75 SKG 250 VAN	1,000	4.5%	1,046
2009 Update							
Serenade of the Seas ^	Alfa Laval 650	Desal 0	0	400 SKG! 400 JNU!	650	14%	764
*Note: Bunker Ports not identified /JNU=Juneau/KTN=Ketchikan /SKG=Skagway/VAN=Vancouver [BC] ^= Data confirmed by RCL for 2009 season. ! = Not identified per period week day?							

Technical Water

- RCL did identify the use/presence of technical water. HVAC system condensate water is used on board for dedicated systems.
- In later responses, RCL identified that technical water was also used in laundry operations; RCL will likely cease use of technical water in the laundry.
- RCL believes that technical water is an “immaterial” amount of the total water used and is, in most cases, used only on one ship. (See Notes.)

Notes:

  - Celebrity Infinity uses technical water (2008 reporting). RCL did not identify when the use of this water use in laundry. Nor did RCL identify the characteristics of this water.

6.2.2. Chemical Use/Process Evaluation

Actions included in SRE

- Review of hotel procedures, and evaluation of pesticides and rodenticides used on board.
- RCL uses only non-toxic pest management products that are unlikely to enter the waste water stream.
- A review of the use of onboard chemicals was conducted, focusing on chemicals that may be introduced into the BW and GW waste water systems.

- RCL reported that their cleaning chemicals do not contain metals and do not contribute to metal loads. Some floor and carpet cleaners do contain ammonia and zinc. Evaluation to minimize these products in the GW stream is under investigation.
- 2009 (pre-season) responses identified that RCL was still waiting for suppliers to respond. The project was 95% complete. Also the results of the project ADEC workshop will be factored in to future responses.
- In 2009 (end of season), over 1,000 products were evaluated. Floor cleaners, Vector and Plaza Plus contain small qualities of Zinc. Guest accommodation updates were made with regard to product contents, and discouraged guests from introducing personal care products in the GW and BW water systems.
- RCL believes that chemicals currently used onboard do not contribute to the metal loads.

Notes:

- Product substitution and implementation of a new chemical inventory was not included in initial SRE.
- Use of piping de-scalers or other drain system chemicals was not identified.

6.3. Treatment Technology Evaluation/Implementation

The RCL fleet has three types of AWTS system, the Scanship system, Zenon system, and Hydroxyl system. Below is a concise description of the Scanship AWTS system provided:

1. Scanship System: is discussed under the NCL review. RCL has a similar system on board. However, the NCL Norwegian Star has undergone significant process changes to improve the ammonia performance.
2. Zenon system: is discussed under the HAL review. RCL has a similar system installed on the Infinity. This was a “compact Zenon” system that includes an oxygen-supported waste water treatment process.
3. Hydroxyl system: Is an AWTS system that is not used (as discharge operation GP) in Alaska waters. The Hydroxyl system has a course screening, screening stage and biological reactor (integrated fixed film activated sludge/IFAS unit). The fixed film looks like gear wheels, which gives the bacteria a surface on which to adhere to aid in breaking down any solids. Afterwards, the bioreactor flotation units remove the remaining solids. After the solids are removed, a polishing filter (barrier) is used, followed by UV treatment. Then the water is discharged.

Evaluation

RCL identifies that the approximate mixing ratio for all the vessels is in the 1:12 to the 1:20 ratio BW/GW. RCL also mentioned that a new generation AWTS system will be installed on the Rhapsody of the Seas.

The Rhapsody of the Seas was selected for installation of a new AWTS system: the Navalis AWTS system. This new system is not known to ADEC and relevant sampling data could not be provided. RCL was working with Navalis to get this system working. From the limited information ADEC received about this system, it appears to be an "ozone" based waste water treatment system. RCL suggested in the reporting that the Navalis also could "reduce/remove" significant amounts of metals. However, RCL could not provide technical "back up" for these findings.

RCL also evaluated promising "new" technologies, and identified ion exchange and Reverse Osmosis, specifically. "*At this point reverse osmosis appears the most promising method of removing the metals down to the required part per billion levels"*. RCL also identified the "reject streams of reverse osmosis systems". However, absent additional, detailed information, the Department could not evaluate these statements and the presence of additional stream volumes.

In 2009 RCL updated the SRE plans and decided only to discharge in 2009 with the Serenade of the Seas and the Rhapsody of the Seas. The latter vessel is equipped with new AWTS technology, the Navalis AWTS. However, during the 2009 season, no sample of the Navalis system was produced, so further revaluation of RCL statements and Navalis effluent performance was not possible.

Pre-season 2009 reporting included that the Navalis system was delayed and RCL is working on it. RCL is also investigating the use of different pH and flocculants combinations for metal removal. See Notes.

Notes:

- Details for specific AWTS and operations for each system were not provided.
- RO systems are reported under technology evaluation "as new". RCL did not include specific data about their experiences/results of Rochem (RO system) operations.
- Navalis system could, according RCL suggestions also, reduce and/or remove metal loads. However, this could not confirmed by Navalis.
- Navalis Company could not be reached for detailed additional information of the RCL AWTS project.

- The Navalis system on board the Serenade of the Seas appears to be a prototype and USCG/Classifications remains unclear.
- RCL did not "expand" on the idea that RO also can reduce metals/metal loads.

Table R5
BW Generation per RCL Fleet
Vessel per VSSP - NOI

Vessel	Pax	Crew	BW VSSP m3/day	BW generation person /day gal	AWTS System Cap m3/day
Celebrity Infinity	1950	930	60	5.5	960
Celebrity Millennium	2454	1001	35	2.7	960
Serenade of the Seas	2100	850	40	3.6	1000
Radiance of the Seas	2500	960	80	6.1	1000
Rhapsody of the Seas	2638	782	120	9.3	Unknown

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7. SEVEN SEAS MARINER SRE OVERVIEW

Table S1 provides an overview of the by the Seven Seas Mariner (SSM) provided documentation for the 2008 and 2009 cruise season. Please note this includes a global overview of the documentation.

Table S1
2008 2009 Season
SRE SSM Documentation Global Overview

Cruise Line	Reports Year 2008	Reports Year 2009	ADEC Questions Comments	Cruise Line Response	ADEC Summary
SSM	Yes S /4/4/08		Yes L 7/28/08	Yes LD 8/13/08	-
	Yes S 8/13/08		-	-	Yes ADEC SSM Review SRE update 8/13/08
	Yes A 1/28/09*		-	-	-
		Yes A 1/10	-	-	Yes ADEC SSM Review SRE 1/15/10

Note: *=Date of report; A=Annual Report; S=Start SRE application; L = Letter; D=Document; and PR=Pre Season Report

7.1. Global Elements Summary of the Submitted SRE Report 2008 2009:

The main groups of SRE items for SSM are listed below in Table S2; group items were used by most, if not all, operators in their SRE related reporting in 2008 and 2009. SSM provided to the point SRE reporting using a similar format (table); achieved progress was clearly demonstrated and verifiable during the SRE reporting periods. SSM reporting style and action plan appears to be focusing in actions to be taken onboard, rather than describing possible scenarios.

In 2009, Ocean Rangers reported that the SSM crew was actively working on the SRE implementation and actively replacing, and were aware of the SRE. Open dialogues were conducted and idea shared.

Table S2
2008 2009 Season
Reporting SRE SSM Main Groups

Main Group	
	Description concise
I. Influent Source Reduction	[waste water flows to AWTS System]
a. Source Water Evaluation	[sources contributing]
b. Chemical Use/Process Evaluation	[use of Hotel Engine room Chemicals]
c. Water Supply Evaluation	[evaporator/Bunker water/Treatment]
II. Treatment Technology Evaluation/Implementation	[new/improved technology]
III. AWTS operations/optimalization/data	[AWTS specific]

7.1.1. General Vessel Operations

Describes the water/bunkering etc. All operations described are in relation to the SRE plans.

7.1.2. Vessel SRE Items Reports Results

Table 1 provides an overview of the cruise lines that provided SRE reports and performed actions on board; below is a concise description given of the reported SRE items and which specific vessel information was obtained.

Table S3
2008/2009 SSM
Status*

2008 2009 Season:	Vessel Name	Year Delivery	AWTS Type/Units Cap m3	2008 Discharge Status	2009 Discharge Status
	Seven Seas Mariner	2001	Hamworthy 240C 360 [2 x 180]	D	D
Notes: ND=Non Discharger D=Discharger *=Vessels that participated in SRE Reporting per season.					

7.2. Influent Source Reduction

7.2.1. Source water evaluation

Three main groups:

- Bunkered water from Shore facilities;
- Evaporator water produced on board; and
- Technical water produced on board.

The SSM has two fresh water distillers (evaporators) made by Serck Como (MSF 400-S), the capacity is 400 m3/day.

SSM included in their initial SRE plans to fine-tune bunkering strategies and ports. Bunker water sampling was also planned. The results of the bunker water source evaluation are discussed separately.

For the 2009, season fresh water production onboard was expected to increase. Reporting in 2009 showed that bunkering in Alaskan ports was significantly decreased and optimal water was produced onboard at a rate of 360 m3/day (on average).

A new potable water regime, (conditioning of potable water), was used in 2009. This was achieved using a combination of soda ash, acid, and potable water stabilizers. This method appears very successful in reducing metal loads.

In order to minimize corrosion of the piping systems on board for potable water, including the drain piping, the vessel closely monitors corrosion, and uses a Unitor potable water conditioner to stabilize the water. This product is dosed in the piping system.

Piping monitoring for corrosion is already a part of the vessel maintenance and operations system.

Notes:

- o Chemicals are most likely used in the evaporator system. It appears that these chemicals are used in the overboard circuit from the evaporator. It is not identified if the chemicals are "carried over" into the potable water circuit. Also, it was not identified if chemicals are used in the evaporator on the "distilled water side" (potable water circuit).
- o It appears that the SSM is actively monitoring the piping systems and replaces sections as necessary.

Table S4
SSM Systems and piping materials

BW system	Material	GW system	Material	Potable water	Material
Toilets/ urinals/hospital /drain sink	Stainless steel	Sink/drain/baths/ shower/suite	Stainless steel	Distribution system	copper
		Galley sink drains		Bunkering/engine spaces	Galvanized steel
		Pulpers		Technical water	Galvanized steel/copper
		Laundry sinks drains			
		Jacuzzis			

Table S5
SSM Alaska Water
2008 Operations [average]

Vessel	Water Bunkering Port [m3 voyage*]					
	VAN	KTN	JNU	SKG	SWD	Consumption 7 day voyage day m3^
Seven Seas Mariner	600	710	530	340	810	427
	Evap cap m3/day					
	400					
*Note: Assumed bunkering regime per voyage ^=estimated by ADEC preliminary						

Technical Water

- SSM identified in the description that technical water piping systems exist. However, detailed information in initial SRE plans regarding this system was not included.

Notes:

- o SSM appears to control this technical water quality with water treatment (preliminary).

7.2.2. Chemical Use/Process Evaluation

Evaluation

- SSM did an inventory of the onboard used chemicals/cleaners. In the initial SRE, it was indentified that SSM was evaluating replacement and the benefits of replacing chemicals used in laundry as washing softener.
- The listed inventoried chemicals did not include tangible traces of heavy metals.
- With regards to the Halogens group (chlorine, bromine, Iodine, Astatine, fluorine), only chlorine and bromine are contained in the chemicals used on board.
- Chlorine in sodium hypochlorite, the “laundry destainer” used onboard, and “Ecostan”, used in the laundry, galley, and housekeeping areas. Sodium hypochlorite is also used in the swimming pool and jacuzzi.
- The internal pipe cleaner used is BIO ET (Hepburn). It is used on a regular basis; the Bio Scale Zapper (Hepburn) is used on quarterly basis.
- Reduction for 2009 of laundry chemicals was planned, as well as a more efficient use of chemicals.
- The 2009 report included chemical use per cruise (volume per product).

Notes:

  - Product substitution and implementation of a new chemical inventory was not included in initial SRE.

7.3. Treatment Technology Evaluation/Implementation

The SSM is fitted with two AWTS systems (units) of the Hamworthy type, the MBR systems. Similar systems are installed on the Alaska Princess Fleet Vessels.

The Hamworthy MBR system on the SSM is described as follows:

The MBR operates as an aerobic biological treatment system. Incoming waste water is fed into a high strength biomass within which there is a diverse microbial ecology that breaks down and consume raw sewage. The by-products are water and carbon dioxide. Water passes through the membrane and is discharged, while the carbon dioxide is vented outside along with the air that is used for the aeration of the biomass. The membrane module contains large numbers of ultra filtration tubes designed to achieve very high permeate production under the cross-flow scouring velocity. The MBR 240C holds a certificate of approval from Bureau Veritas (BV) and is in compliance with the IMO MEPC-2.

Operations SRE

SSM indentified that it adopted operational practices to reduce pollutants. Procedures that reduce the ammonia by biological reduction, increase the waste water retention onboard and reduce the load on the MBR treatment to maximize the waste water treatment process of the unit have been implemented. This is possible due the holding capacity.

The current mixing ratio BW/GW is 5/95, and is already optimized not to affect the effluent quality. The MBR units are operated at a less than maximum daily flow of180 m3/day per unit. This is well below the manufacturer maximum capacity of 240 m3/day per unit.

The tanks to hold waste after are coated with Jotun epoxy tank guard 412 paint. This coating is a solvent-free product.

Table S6
BW GW Generation Seven Seas Mariner VSSP
2008 2002

Vessel	BW m3/ day	GW m3/day	Pax	Crew	Total Volume Person m3/day	AWTS processed estimated	BW GW 5/95 ratio^	
Seven Seas Mariner	17	350	769	431	0.305	360 [2 units at 180]	Yes	
^ = assumption that 5/95 is 5 % BW 95 % GW								

8. SILVER SHADOW SRE OVERVIEW

Table SS1 provides an overview of the Silver Shadow (SS) provided documentation for the 2008 and 2009 cruise season. Please note this include a global overview of the documentation.

Table SS1
2008 2009 Season
SRE SSM Documentation Global Overview

Cruise Line	Reports Year 2008	Reports Year 2009	ADEC Questions Comments	Cruise Line Response	ADEC Summary
SS	Yes S 8/1/08		Yes L 8/1/08	Yes S 10/31/08	Yes ADEC SS Review SRE 8/1/10
	Yes S 10/31/08		-	-	-
	Yes A 1/14/09*		-	-	-
		Yes A 1/14/10	-	-	Yes ADEC SS Review SRE 1/15/10

Note: *=Date of report; A=Annual Report; S=Start SRE application; L = Letter; D=Document; and PR=Pre Season Report.

8.1. Global Elements Summary of the Submitted SRE Report 2008 2009

The main groups of SRE items for SS are listed below in Table S2; group items were used by most, if not all, operators in their SRE related reporting in 2008 and 2009. SS provided to the point SRE reporting using a similar format (table); achieved progress was clearly demonstrated and verifiable during the SRE reporting periods. The SS reporting style and action plan appear to be focusing on actions to be taken onboard rather than describing possible scenarios, and showed clear progress.

In 2009 Ocean Rangers reported that the SS crew was actively working on the SRE implementation and actively replacing piping and "looking for metal loads producing sources".

Table S2
2008 2009 Season Reporting SRE SSM Main Groups

Main Group	
	Description concise
I. Influent Source Reduction	[waste water flows to AWTS System]
a. Source Water Evaluation	[sources contributing]
b. Chemical Use/Process Evaluation	[use of Hotel Engine room Chemicals]
c. Water Supply Evaluation	[evaporator/Bunker water/Treatment]
II. Treatment Technology Evaluation/Implementation	[new/improved technology]
III. AWTS operations/optimalization/data	[AWTS specific]

8.1.1. General Vessel Operations

All operations described are in relation to the SRE plans.

8.1.2. Vessel SRE Items Reports Results

This section includes a concise description of the vessel operations.

Table 1 provides an overview of the cruise lines that provided SRE reports and performed actions on board; below is for each cruise line per season a concise description given of the reported SRE items and which specific vessel information was obtained.

Table S3
2008/2009 Silver Shadow Status*

2008 2009 Season:	Vessel Name	Year Delivery	AWTS Type/Units Cap m3	2008 Discharge Status	2009 Discharge Status
	Silver Shadow	2000	Marisan Biopure 300 [2 x 25/250]	D	D
Notes: ND=Non Discharger D=Discharger *=Vessels that participated in SRE Reporting per season.					

8.2. Influent Source Reduction

8.2.1. Source water evaluation

Three main groups:

- Bunkered water from Shore facilities;
- Evaporator water produced on board; and
- Technical water produced on board.

Silver Shadow produces water, and also started to sample their water to determine potable water quality.

Anomalies of Metal Loads Found by Sampling

GW system appears to be contributing to relatively high copper results. A sampling strategy was set up to pinpoint the source of the copper load.

Contributions by cupronickel piping, planned maintenance, and a pressure controlling device were determined. The device appears to be contributing to the metal loads; in fact, the “hammering” of metal parts suggests it was a substantial contributor to metal loads.

Repairs/Planned Maintenance to be Made

- Silver Shadow continued to track points of metal loading in the off-Alaska season. After the pressure valve, the laundry and AC condensate appear to be potential high load sources for copper.
- New action is a vessel obtained sample test kit Hach DR 890 for copper and nickel detection. Crew is now engaging in self-testing and pin pointing sources. In 2009, this tool was extensively used. However, new sources of metal were not identified. Monitoring will continue.
- For dry docking 2011, specifications are made for pipe replacement.
- Silver Shadow identified that the ACA also had bunker water reporting.
- New action is a modification plan to replace piping in Laundry and AC condensate system. The proposed action plan includes moving laundry water to retention tanks and storage. AC condensate has two branches: forward and aft. The total flow of this condensate is estimated at 1.7 m3/day. This water is going to the laundry as technical water. These flows are diverted and will not discharge in Alaska water (re-pipe).
- Potable water sampling in the initial SRE and during the 2008 season additional sampling in SE Alaska bunker ports. Corrosion effects are possible with chlorine, and water temperature (heaters). Bunker load of water between the Canadian Ports and Alaska is 26.4 % versus 73.6%. According SS, the ports with the lowest metals are SKG, Van, and KTN.
- The Silver Shadow was the only vessel in 2009 and 2008 that relied on its own sampling from bunker water. The Silver Shadow also appears to correlate the bunker water sampling results (water bunker in Alaska). See Table SS6.
- Potable water/Bunker water strategies are developed to minimize metal loads.
- Pipe monitoring for corrosion is already a part of the vessel maintenance/operational system.

Notes:

- Chemicals are most likely used in the evaporator system. It appears that these chemicals are used in the overboard circuit from the evaporator. It is not identified if the chemicals are “carried over” into the potable water circuit. Also, it was not identified if chemicals are used in the evaporator on the “distilled water side” (potable water circuit).
- It appears that the SS is actively monitoring the piping systems and replaces sections as necessary.
- It appears that the SS has dedicated engine room team working on pinpointing the metal sources.

Table SS3
Sample results Silver Shadow Sources 2008

Location D ate 6 /6/08 9/8/08	Cu ug/L	Ni ug/L
Evap I PS	17.7	4.18
	55	29
Evap II ST	19.9	5.42
	32	8.0
RO tank	-	-
	5.3	2.5
FWD tank 3SB infl.	0.602	2.24
	-	-
Domestic Heater outlet	-	-
	30	57
GW inlet Marisan	-	-
	110	11
Deck 3 Hot Water	26.1	16.6
	35	9.1
Deck 5 Cold Water	6.38	1.59
	18	3.0
Deck 9 Hot Water	25.9	17.2
	40	8.6
FW Bunker station	0.345	<0.15
	-	-
FW Tank 4 ST	2.25	1.29
	-	-

Technical Water

- Silver Shadow identified in the description that technical water piping systems exists. However, detailed information was later reported and showed that these flows are “copper load” flows, and are diverted and not used in the laundry any longer. Instead these flows are discharged in Alaska waters.
- Silver Shadow appears to control this technical water quality with water treatment (preliminary).

8.2.2. Chemical Use/Process Evaluation

Evaluation

- Inventoried and collected all datasheets of used chemicals on board. Analysis made of these products. All records sheets show no direct relation with metals. Unable to relate.
- Paint analysis of used paints coating that could contribute to the metal loads. Unable to relate metal loads to the used coatings.
- In 2009, project was completed and product exchanges have been made. The product Solid Power Dish Wash and Balance Fushion, (containing zinc), has been replaced.
- Process of chemical evaluation (for new products) will be continued in 2010.
- All water tanks that contained “copper pigments” are re-coated with two-component solvent-free amine-cured epoxy coating.

8.3. Treatment Technology Evaluation/Implementation

The SS is fitted with two AWTS systems (units) of the Marisan type, a system that is not installed on other vessels in the Alaskan trade.

The SS consulted the Italian manufacturer of the AWTS system for advice to reduce ammonia and metal load. The chemicals used in the process were also evaluated. Additionally, the option of other (add on technologies) of metal removal is being investigated by the WTS manufacturer. It was reported that the vendor could not provide additional or different operational instructions. Different chemicals used for the AWT process could not be offered. Upgrade suggestions on the existing systems could was not offered, either.

Table SS4
BW GW Generation Silver Shadow VSSP
2008 2009

Vessel	BW m3/ day	GW m3/day	Pax	Crew	Total Volume Person m3/day	AWTS processed estimated	2008 Bunkered water AK	2008 Bunkered water CAN
Silver Shadow	25	225	435	305	0.337	250	73.6 %	26.4 %
^ = assumption that 5/95 is 5 % BW 95 % GW								

Table SS5
Silver Shadow Bunker water sampling Alaskan Canadian Ports
2008

Alaska				
Location Date				
Pollutant	KTN [9/10/08]	WRG [9/7/08]	JNU [8/30/08]	SKG [9/10/08]
Cu ug/L	2.3	7.7	70	2.4
Ni ug/L	<1.0	4.3	17	7.8
Canada				
Location Date				
Pollutant	Victoria [9/04/08]	Vancouver [9/5/08]		
Cu ug/L	21	1.7		
Ni ug/L	<1.0	<1.0		

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9. ACA POTABLE WATER STUDY

In 2008, The Alaska Cruise Association (ACA) conducted a bunker water sampling project for the member cruise lines. The goal was to collect potable water from shore facilities in port where vessels bunker (take in) bunker water on a regular basis.

The results of the sampling of the sources/references were made in most of the SRE reporting by the cruise lines. The ACA retained Admiralty Environmental to conduct sampling in several ports. The goal appears to have been to determine where the sources of the metals come from. The sample events included sampling for copper, nickel, and zinc.

Table 1 include an overview of the ports were potable water/bunker water was sampled.

Table 1
Sample Locations Port

Port	Cu Ni Zn	Qty	Notes
San Francisco	Yes	7	
Seattle	Yes	23	
Victoria [BC]	Yes	12	
Vancouver [BC]	Yes	28	
Ketchikan	Yes	21	
Wrangell	Yes	1	ACA was not aware of 2008 cruise ship visits
Juneau	Yes	24	
Haines	Yes	1	ACA was not aware of 2008 cruise ship visits
Skagway	Yes	23	
Whittier	Yes	6	
Seward	Yes	6	

Note: Based on ACA information 2 3 09 ACA ADEC. PDF picture format. Quantity approximate.

9.1. Bunker water/Potable water from Shore

Cruise vessels bunker (take in) potable water in ports; they also produce potable water onboard by using evaporators and reverse osmosis systems. The volumes of potable water bunkered in Alaska vary greatly. Table 2 and Table 3 provide an overview of the volumes of bunkered water compared to the total water volumes used onboard.

Table 2
HAL Fleet 2008
Potable Water
Sources Volumes Percentage

Vessel	Produced Water Volume %		2008 Season Bunkered Water Volume % Port							Vessel Class
	E water	T water	SEA	VAN	KTN	JNU	SKG	HNS	SWD	
Oosterdam	78	-	5	-	11	7	-	-	-	V-Class
Westerdam	81	-	-	-	12	7	-	-	-	V-Class
Ryndam	34	13	-	15	19	6	13	-	-	S-Class
Statendam	52	-	-	24	14	1	9	-	-	S-Class
Veendam	31	-	-	18	19	6	8	3	15	S-Class
Volendam	47	2	-	6	10	7	4	9	16	R-Class
Zaandam	41	-	-	4	13	9	5	10	17	R-Class

Table 3
PCL Water Sources Volumes %
Alaska Fleet

Vessel	Evaporator Water %	Bunkered Water %	Comments
Coral	72	28	
Diamond	53	47	
Golden	70	30	
Island	71	29	
Pacific	65	35	
Sapphire	53	47	
Sea	78	22	
Star	68	32	
Sun	Not visiting in 2009		
Dawn	Not visiting in 2009		

Water is bunkered from a trusted source and is, in most cases, if not all, from the municipal water utility. The water lines (mains) are extended to the docking locations, and a connection is made with a portable water hose. In some cases, the water is metered (water meter) to register the bunkered water volumes. In some locations, (e.g. Juneau), a fire hydrant is used as the tap point for the water bunkering operation. The water utilities sample their water as well; however this sampling (regulatory) is in most cases done at residential homes by including the residential home piping in the sampling circuit, or may be done at the water handling plant.

Table 4
Bunker water Sample results
Selected Ports*

Port Location	Date	Cu ug/L	Ni ug/L	ZN ug/L	Notes
San Francisco	7/16/08	0.83	<0.5	<5	PCL sample
San Francisco Pier 35	8/26/08	3.4	<0.5	250	ACA sample
Seattle North Berth PCL	6/30/08	34	1.3	2600	PCL sample
Victoria Pier A south	8/26/08	7.0	<1	<5	ACA sample
Victoria Pier B North	8/26/08	7.0	<1	16	ACA sample
Victoria	6/21/08	2.47	0.431	8.92	PCL sample
Victoria	6/5/09	2.6	2.8	120	PCL sample
Vancouver North Con	7/24/08	1.5	<0.2	209	PCL sample
Vancouver Central Con	7/24/08	15	<0.2	280	PCL sample
Vancouver South Con	7/24/08	7.8	<0.2	6.0	PCL sample
Vancouver Can Place East	8/27/08	110	<1.0	<5	ACA sample
Vancouver Can Place West	8/27/08	4.0	<1.0	12	ACA sample
Ketchikan	6/17/08	3.62	0.212	4.14	PCL sample
Ketchikan St. FWD Port	6/17/08	0.43	0.2	6.49	PCL sample
Ketchikan Berth 2	8/29/08	<1	<1	3.4	ACA sample
Ketchikan Berth 4	8/29/08	2.2	<1	10	ACA sample
Ketchikan Berth 3	8/29/08	1.3	<1	16	ACA sample
Juneau AJ Dock	6/18/08	28.1	1.24	13.7	PCL sample
Juneau AJ Dock	7/21/08	58.4	0.771	26.8	
Juneau South Franklin dock	6/25/08	41.7	2.35	16	PCL sample
Juneau South Franklin dock	6/1/09	2.2	1.3	33	PCL sample
Juneau South Franklin Dock	8/18/08	280	2.9	77	ACA sample
Juneau South Franklin Dock	8/11/08	2.3	0.46	13	ACA sample
Juneau AK SS dock	9/4/08	34	1.2	75	ACA sample
Skagway	6/12/08	0.688	1.48	6.53	PCL sample
Skagway	6/2/09	3.2	1.5	49	PCL sample
Skagway RR dock	8/26/08	20	22	54	ACA sample
Skagway Ore station Dock	8/26/08	2.3	2.2	13	ACA sample
Haines	9/17/08	2.1	<1	<20	ACA sample
Whittier	9/11/08	1.2	<1	7.6	ACA sample
Seward	8/15/08	9.5	0.26	6.1	ACA sample
Seward	7/30/08	0.904	1.46	6.91	ACA sample

Note: Selected from Princess Cruise Lines SRE Reporting (08/09) and ACA Bunker water Synopsis 2008.

9.2. Discussion of sample results/ADEC Findings

ACA retained Admiralty environmental to conduct the sampling. The following are actions taken and findings made by ADEC:

- The majority of samples were taken in the period after July, August and September, and did not include “early season sampling”.
- ACA did not develop a dedicated sampling plan or “bunker water specific sampling plan” that included sampling locations and methods. In lieu of such plan, the ACA used the NWCA QAQC plan that is used for waste water sampling. Although the NWCA QA QC plan was used, duplicate sampling, as required by the QA QC plan, was not performed by ACA.
- Description of locations is included in the results, but details (including connection pieces, fittings, water meters and other fixtures that could contribute to the metal load) were not included in the description.
- ACA attempted to sample the bunker water during bunkering of the vessels; however a large number of the sampling events (approximately 72) were not correlated to active vessel bunkering. In any case, a clear correlation of sample results to specific vessels and effluent in a particular sample event could not be made.
- ACA provide the sample results in PDF format, and was therefore not directly accesible for further assessment and analysis.
- ACA indentified that an initial frequency of weekly sampling of bunker water was planned. However, logistical difficulties and limited access to certain ports appears that this goal could not be met.
- Ports were not able to provide bunker water data to ACA.

9.3. Conclusion

Bulk sampling of large quantities of potable water requires a “tailor made” sampling plan. ACA appears to have never discussed with the appropriate parties in early stage their plans to perform the bulk sampling efforts. It also appears that the sample results at certain bunker locations have extremely high metal values, while in the same port on another location the values are relatively low. A good example is the Port of Skagway, where sample results for the metals at the Railway Dock appear to be extremely high compared to other bunker points in Skagway (Broadway Dock/Ore Station Dock). Sample locations in the bunker port itself are important. As an example, Skagway and Seattle have large difference in metal loads, depending on where at the port a sample was taken.