



June 27, 2014

Mr. Rob Clarke
Executive Vice President and Chief Financial Officer
British Columbia Ferry Services Inc
Suite 500-1321 Blanshard Street
Victoria, BC
V8W0B7

Re: Intermediate Class Vessel Project Contract Award

In response to your attached letter of June 24, 2014 and your recent presentation to us regarding the top proponent's design and key features of the new vessels, we confirm the following conditions have been satisfied:

- a) The actual design of the vessels, which will be dual-fuelled (liquefied natural gas and marine diesel oil), is as generally described in the Application referred to in Order 13-01;
- b) The cost of the new vessels does not exceed the maximum amount set by confidential Order 13-01A;
- c) BC Ferries has confirmed that the successful proponent will meet or exceed the fuel efficiency target of 6.5% set out on the RFP.
- d) BC Ferries has demonstrated that the design of the new vessels incorporates features that will mitigate sea spray on the decks including high bulwarks, large bow visors at both ends of the vessels and an enclosed lower deck. With these features, coupled with BC Ferries' operational experience on the routes, it can reasonably be expected that the decks will be free from sea spray 95% of the time in typical operational conditions during winter/spring conditions as indicated by the Commission's independent naval architect in their attached report. Additionally BC Ferries remains committed to providing notification to vehicle operators on days when there is a reasonable likelihood of sea spray on a vehicle deck.
- e) A contingency plan is in place to mitigate the delay in the delivery dates proposed in the Application.

Accordingly, the BC Ferry Commission has no objections to BC Ferries proceeding with finalizing a contract with the successful proponent for the construction of the three new vessels approved by Order 13-01.

A handwritten signature in blue ink that reads "S. T. Stoilen".

Yours truly,
Sheldon Stoilen
BC Ferries Deputy Commissioner

June 24, 2014

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Mr. Sheldon Stoilen
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BC Ferry Commission
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Dear Mr. Stoilen:

Intermediate Class Vessel Project – Contract Award

On May 22, 2013, British Columbia Ferry Services Inc. ("BC Ferries" or the "Company") filed an application pursuant to section 55(2) of the *Coastal Ferry Act* seeking the approval of the British Columbia Ferries Commissioner (the "Commissioner") of a proposed major capital expenditure for the design and build of three new intermediate class vessels to replace vessels currently operating on route 9 (Tsawwassen-Southern Gulf Islands) and route 17 (Powell River-Comox/Little River) (the "Application").

By Order 13-01 dated July 19, 2013 the Commissioner approved the proposed major capital expenditure for the acquisition of the three new intermediate class vessels, as generally described in the Application, subject to certain conditions, including the following:

Prior to signing a final contract with a shipyard for the design and build of the proposed new vessels, BC Ferries must:

- (i) satisfy the commissioner that the actual design of the vessels is as generally as described in the Application and the cost does not exceed the maximum amount approved by the confidential order referred to in paragraph 1(a) above;*
- (ii) obtain the commissioner's approval to select diesel-fuelled vessels rather than LNG-fuelled vessels, and in that event, submit a final comparison of life cycle costs on a net present value basis for the lowest cost diesel-fuelled option and the lowest cost LNG-fuelled option; and*
- (iii) provide the commissioner with a contingency plan to mitigate a delay in the delivery of the new vessels beyond the delivery dates proposed in the Application.*

By correspondence dated December 10, 2013 (Attachment 2) the Commissioner established additional conditions as follows:

- (iv) *BC Ferries must, before signing a contract, confirm that the successful proponent will meet or exceed the fuel efficiency target set out in the RFP.*
- (v) *BC Ferries must, before signing a contract, demonstrate to the Commission's satisfaction that the final design will ensure that the decks will be free from sea spray 95% of the time in normal operating conditions up to Beaufort Sea State 5.*
- (vi) *BC Ferries remain committed to providing notification to vehicle operators on days when there is a reasonable likelihood of sea spray on a vehicle deck.*

BC Ferries has recently completed the Request for Proposal ("RFP") stage of the procurement process for the intermediate class vessels. BC Ferries intends to enter into contract with the top proponent, Remontowa Shipbuilding, S.A. of Gdansk, Poland, hereafter referred to as the "Builder". Our compliance with the conditions precedent to contract award as set out in Order 13-01 and the Commissioner's correspondence of December 10, 2013 are addressed below.

The actual design of the vessels is as generally as described in the Application and the cost does not exceed the maximum amount set by confidential Order 13-01A.

The Company has negotiated with the Builder for the construction of three 105 (one hundred and five) meter overall length identical dual fuelled passenger "roll on – roll off" ferries of 145 automobile equivalent ("AEQ") and 600 passenger capacity. The estimated total cost of the project is \$16.38 million (Canadian dollars) less than the maximum amount set by Order 13-01A. On a net present value basis ("NPV"), the project cost of - \$493.7 million is \$14.63 million favourable to the estimated NPV cost for vessels fuelled by liquefied natural gas ("LNG") of - \$503.88 million in the Application.

The proposed design meets all of BC Ferries' requirements as specified in the RFP and is generally as described in the Application. The one variant in design to that set out in the Application relates to the vehicle capacity of the third vessel, which is intended for relief and seasonal augmentation. The Application envisaged and the RFP stipulated that the third vessel be designed and built to a lower capacity of 125 AEQ, in lieu of 145 AEQ, in an effort to reduce overall cost. Similarly, it was anticipated that the route 17 vessel might have a different set of passenger amenities than the route 9 vessels. All proponents indicated that such stipulations would result in higher cost due to design variation and the lost efficiency of a series build. Accordingly, BC Ferries has opted to have all three vessels built identically in order to reduce overall project cost and maintain full standardization. In all other respects, the dual-fuel LNG and Marine Diesel Oil ("MDO") gas electric ferries conform fully to the design described in the Application and the RFP requirements. The dual-fuel design has the added potential benefits of reducing operating costs, when operated on LNG, and reducing the environmental impact by using LNG which is a cleaner fuel source as compared to MDO. With regard to the passenger amenities, the vessels will be configured such that food and retail services can be closed off and isolated when not required.

The three intermediate class vessels are being designed and built for a 40 year lifespan with a mandate to be flexible and interoperable across current and potential routes that may arise in the future. To maintain overall operational flexibility the design has included crew live aboard for up to 16 crew members. The operational decision to commence using the live aboard feature will depend on numerous factors where route assignment, existing amenities and operational efficiencies, among others, will be fully considered. This operational flexibility has been achieved within a total project cost that is well below the amount approved by the Commissioner.

The vessels will be dual-fuelled (LNG and MDO).

The Company's reasoning for stipulating dual-fuelled vessels, rather than a single source of LNG only, is two-fold. The primary reason is to reduce overall risk since the LNG supply is not fully established in all forecasted operating locations. Secondly, dual-fuel will allow for greater operational flexibility in the event that LNG is not available in all operating locations.

A contingency plan is in place to mitigate a delay in the delivery of the new vessels beyond the delivery dates proposed in the Application.

The Builder has proposed vessel delivery dates based on a contract signing on or before July 3, 2014; in this scenario the first vessel is delayed to August 1, 2016 as compared to the December 2015 to April 2016 timeframe referenced in the Application. Vessels two and three will be delivered October 1, 2016 and February 1, 2017, respectively, as compared to the June 2016 to October 2016, and December 2016 to April 2017 timeframes for these vessels referenced in the Application.

BC Ferries' contingency for the delay of the first vessel is assured by extending the operational cycle of the *Queen of Burnaby* as needed, and deploying other assets in relief. The extension of service for the *Queen of Burnaby* can be accomplished by invoking additional maintenance requirements at scheduled maintenance periods, and by seeking a Transport Canada Marine Technical Review Board decision to allow it to continue in current service until the new vessel can be declared fully operational and ready for service. This approach is considered low risk, and BC Ferries will undertake all necessary efforts to ensure that the classification and regulatory requirements are fully met, while ensuring that safety remains paramount, if this contingency is required.

The fuel efficiency target stipulated in the RFP is expected to be met.

The fuel efficiency target for the new vessels in the RFP was set relative to the current vessels, the *Queen of Burnaby* and *Queen of Nanaimo*. The RFP stipulated that the new vessels are to be at least 6.5 percent more efficient than the current vessels on average and the Builder has indicated, based on hull form and propulsion system configuration, that the proposed dual-fuel LNG /MDO vessels are expected to meet or exceed this target. The target is included in the contract with the Builder as a requirement to be met and is subject to liquidated damages being applied. The actual fuel consumption of the vessels will be determined during contracted sea trials with actual operating conditions and additional trial machinery instrumentation. The sea trial results will be compared against existing historical data to determine the actual versus the predicted efficiency. It is expected that the target set in the RFP and specified in the contract will be achieved with a good margin.

The design incorporates features to mitigate sea spray on the deck, which in tandem with the Company's operating experience on the routes, is expected to ensure that the decks will be free from sea spray 95 percent of the time in normal operating conditions up to Beaufort Sea State 5.

The characteristics of Beaufort Sea State ("Beaufort") 5 conditions are as follows:

Fresh breeze	29–38 km/h	2–3 m	Moderate waves of some length. Many whitecaps. Small amounts of spray.	Branches of a moderate size move. Small trees in leaf begin to sway.
	8-10.7 m/s			

This level of sea state was chosen as it most closely represents a "typical" operational condition that BC Ferries could expect to operate in during winter/spring operations before having to invoke any heavy weather precautions. Any worsening conditions would likely result in operational restrictions, up to and including the suspension of operations until conditions improved.

The Builder's design incorporates good design features to mitigate against sea spray on deck. While the ends of the vessel are open, the design incorporates high bulwarks and large bow visors at both ends of the vessel. The design proposed by the Builder has the following characteristics:

<i>Minimum Height of Car Deck Bulwark (m) from WL</i>
9.2m to top of visor
11.6m to passenger boarding deck

Technical references for prediction of spray are limited and principally associated with the prediction of icing. One such reference is *Zakrzewski, W.P. Icing of Ships. Part I: Splashing a Ship with Spray, NOAA Technical Memorandum, USA, 1986 [Reference 1]*, which is a compilation of a number of sources on spray data. The application of the tables from Zakrzewski indicated that for a vessel with 9m bulwarks, airborne spray would only be an issue in conditions above Beaufort 6 [10.8-13.8m/s wind speed, 3-4m waves], as shown in Attachment 1. The referenced table indicates that a very low mass volume (0.01-0.02%) of spray would reach the bulwark height in the referenced conditions.

In terms of developing the confidence interval, BC Ferries contracted to have the data from two Environment Canada weather buoys reduced to generate probabilities of occurrence for wind and wave conditions for routes 9 and 17 [Reference 2]. For spray generation, the emphasis is on wind, particularly as the Beaufort Scale is a wind scale. However, the corresponding occurrence of wave heights is also presented, as there is a time factor associated with developing the required conditions.

The data for Beaufort 5 and 6 conditions from Reference.2 are summarized in the following table:

Wind and Wave Data – Sentry Shoal and Halibut Bank Wave Buoys

Wave Buoy Location:		Sentry Shoal		Halibut Bank	
		Wind Speed	Wave Height	Wind Speed	Wave Height
Beaufort:	5	[8-10.7 m/s]	[2- 3m]	[8-10.7 m/s]	[2- 3m]
Probability of Occurrence:	Winter	15.1%	14.6%	14.9%	21.1%
	Spring	13.8%	15.0%	11.1%	17.8%
	Summer	8.6%	6.9%	8.5%	16.5%
	Fall	11.9%	12.7%	13.5%	19.9%
Averaged*	Annual	12.35%	12.30%	12.00%	18.83%
Beaufort:	6	[10.8-13.8 m/s]	[3- 4m]	[10.8-13.8 m/s]	[3- 4m]
Probability of Occurrence:	Winter	3.9%	8.9%	2.9%	3.9%
	Spring	2.9%	5.6%	1.5%	2.1%
	Summer	1.4%	0.8%	0.6%	0.4%
	Fall	2.7%	6.5%	2.4%	3.7%
Averaged *	Annual	2.73%	5.45%	1.85%	2.53%

* Indicates the probability of occurrence (time) averaged annually. Therefore expect to encounter Beaufort 5 conditions on average 12.35 % of the time, and Beaufort 6 conditions on average 2.73 % of the time.

In developing the table from the data set in Reference.2:

- a. It was necessary to match the wind speed ranges to the Beaufort Scale limits; this may have slightly increased the probabilities of occurrence for the Beaufort 6 conditions.
- b. The stated wave heights in the Beaufort Scale are taken as “observed”, whereas the wave height data in [2] is statistical, as “significant” wave height (H_s , average of $1/3 =$ highest waves). The wave data in the table was generated using a relationship whereby the “observed” was assumed to be a maximum, to correlate with the “significant” values using a factor of two (2). If the Beaufort data is taken as significant values, there was no correlation with the wind speed occurrences, and the number of occurrences was statistically insignificant.

The table indicates that while Beaufort 5 conditions occur relatively frequently, Beaufort 6 conditions and higher are proportionally less frequent, and align with the confidence bands.

In summary, the experimental data in Zakrzewski [1] and the environmental data summarized in the above table (from [2]), it is evident that the 95 percent confidence limit can be met by the Builder’s design, even for Beaufort 6 conditions where:

- (1) There is insufficient mass transfer of spray in Beaufort 5 conditions for the proposed bulwark height such that no significant spray will reach the vehicle deck (see Attachment 1);
- (2) Beaufort 6 conditions occur infrequently; therefore the 95 percent confidence limit is met.

Furthermore, the Builder’s design has a lower car deck with 64 AEO slots with the option of being enclosed with the incorporation of four McGregor type hydraulic doors (two at each end the car deck).

Finally there is the operational experience with the *Island Sky*, which operated successfully on route 17 over the winter of 2013/14 with minimal spray issues despite having an open vehicle deck with conventional 1.3m high bulwarks and open ends fitted with folding gates only.

With the design features proposed for the intermediate class vessels, combined with the Company's operating experience on the routes in question, there is reasonable certainty that the sea spray criteria will be met by the selected proposal.

BC Ferries remains committed to providing notification of sea spray on a vehicle deck.

BC Ferries intends to provide notification to vehicle operators on days when there is a reasonable likelihood of sea spray on a vehicle deck. In the event that conditions do warrant such notification, BC Ferries confirms that proper and timely notices will be made for the routes in question. The inclusion of an enclosed lower deck on the preferred design affords the opportunity to direct up to 64 cars to a sheltered deck.

We trust the foregoing is satisfactory. Should you have any questions or require further information regarding this matter, please do not hesitate to contact me.

Sincerely,



Robert P. Clarke
Executive Vice President & Chief Financial Officer

References:

- 1) Zakrzewski, W.P. Icing of Ships. Part I: Splashing a Ship with Spray, NOAA Technical Memorandum, USA, 1986
- 2) "Wind & Wave Data Reduction for Sentry Shoal and Halibut Bank", STX Marine Canada, Report No.: 165-050-04, Rev.0, 17 Sept.2013.

Attachments:

- 1) Table from Zakrzewski (1986)
- 2) December 10, 2013 correspondence from the Commissioner

Attachment 1: Table from Zakrzewski (1986):

Table 5.--Vertical distribution of the liquid water content (kg/m³) in wave-generated spray computed by improved Borisenkov et al.'s (1975) formula for a given heading angle and ship speed and surface wind speed.

HEADING ANGLE (deg)		1 8 0				1 5 0				1 2 0				9 0		
SHIP SPEED (knots)		5.5	8.5	10.7	12.5	5.5	8.5	10.7	12.5	5.5	8.5	10.7	12.5	5.5- -12.5		
SURFACE	WIND SPEED (m/s) $U_{10} = 10$	ELEVATION ABOVE THE SHIP'S DECK (m)	0	.028009	.035007	.040634	.045550	.026409	.032258	.036919	.040967	.022279	.025323	.027679	.029685	.017204
			1	.016160	.020197	.023444	.026289	.015237	.018611	.021300	.023636	.012854	.014610	.015970	.017127	.009926
			2	.09323	.011653	.013526	.015162	.008791	.010738	.012289	.013637	.007416	.008429	.009214	.009881	.005727
			3	.005379	.006723	.007804	.008748	.005072	.006195	.007090	.007868	.004279	.004863	.005316	.005701	.003304
			4	.003103	.003879	.004502	.005047	.002926	.003574	.004090	.004539	.002469	.002806	.003067	.003289	.001906
			5	.001790	.002238	.002598	.002912	.001688	.002062	.002360	.002619	.001424	.001619	.001769	.001898	.001180
			10	.000114	.000143	.000166	.000186	.000108	.000132	.000151	.000167	.000091	.000103	.000113	.000121	.000070
		ELEVATION ABOVE THE SHIP'S DECK (m)	0	.132779	.158940	.179620	.197480	.126712	.148733	.166002	.180836	.110862	.122572	.131532	.139099	.090921
			1	.076607	.091701	.103632	.113936	.073107	.085811	.095775	.104333	.063962	.070718	.075887	.080253	.052457
			2	.044198	.052907	.059790	.065735	.042179	.049509	.055257	.060195	.036903	.040800	.043783	.046302	.030265
			3	.025500	.030524	.034496	.037926	.024335	.028564	.031881	.034730	.021291	.023540	.025261	.026714	.017461
			4	.014712	.017611	.019902	.021881	.014040	.016480	.018393	.020037	.012284	.013581	.014574	.015413	.010074
	5	.008488	.010161	.011483	.012624	.008100	.009508	.010612	.011560	.007087	.007836	.008409	.008892	.005812		
	10	.000543	.000649	.000734	.000807	.000518	.000608	.000678	.000739	.000453	.000501	.000537	.000568	.000372		
	ELEVATION ABOVE THE SHIP'S DECK (m)	0	.300614	.352042	.392336	.426728	.288603	.332042	.365833	.394697	.257036	.280383	.298149	.313090	.216870	
		1	.713439	.203111	.226316	.246316	.166509	.191572	.211067	.227721	.148297	.161767	.172017	.180637	.125123	
		2	.100066	.117185	.130597	.142112	.096067	.110527	.121775	.131383	.085560	.093330	.099245	.104219	.072190	
		3	.057733	.067610	.075348	.081991	.055426	.063769	.070258	.075802	.049364	.053847	.057259	.060129	.041650	
		4	.033309	.033007	.043472	.047305	.031978	.036791	.040535	.043734	.028480	.031067	.033036	.034691	.024030	
		5	.019218	.022505	.025081	.027293	.018450	.021227	.023387	.025232	.016432	.017924	.019060	.020015	.013864	
		10	.001228	.001439	.001603	.001745	.001179	.001357	.001495	.001613	.001050	.001146	.001218	.001279	.000886	

The data from the table can be difficult to interpret but it is evident that for heights between 5-10m and wind speed of 10 m/s that the mass transfer of spray is very low (0.001-0.002 kg/m³). This indicates that very little spray generated in a Beaufort 5 condition would even reach to top of the bulwark, let alone be carried over onto the vehicles.



December 10, 2013

Mr. Rob Clarke
Executive Vice President and Chief Financial Officer
BC Ferries
Suite 500 – 1321 Blanshard Street
Victoria BC V8W 0B7



Dear Mr. Clarke:

Re: Intermediate Class Vessel Project

Further to your letter of November 27, 2013, the Ferry Commission has no objection to BC Ferries proceeding to RFP at this time.

We have received independent advice from a Marine Architect confirming that:

- a) a reasonable fuel efficiency target has been included in the technical specifications, and;
- b) there is adequate language in the RFP to set out design specifications which must be met, to address ferry user concerns about open deck configuration.

Our approval to proceed to RFP is based on three conditions:

1. BC Ferries must, before signing a contract, confirm that the successful proponent will meet or exceed the fuel efficiency target set out on the RFP.
2. BC Ferries must, before signing a contract, demonstrate to the Commission's satisfaction that the final design will ensure that the decks will be free from sea spray 95% of the time in normal operating conditions up to Beaufort Sea State 5.
3. That BC Ferries remains committed to providing notification to vehicle operators on days when there is a reasonable likelihood of sea spray on a vehicle deck.

Yours truly,

Gord Macatee
Ferry Commissioner

/gd



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Review of the ICF proponents requirements re Fuel efficiency and Deck Spray

26 June 2014

REPORT 13-10D

REPORT 13-10D

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1 INTRODUCTION

The BC Ferry Commission has tasked 3GA Marine Limited (3GA) to review and provide advice on the Intermediate Class Ferry acquisition application. Specifically on technical aspects of the BC Ferry response to the Commissioner's requests regarding verification of fuel efficiency and probability of spray on the car deck.

The charge to 3GA is to review the application and supporting technical data provided by BCFS and provide opinion on;

The design and technical specifications contained in BC Ferries' final procurement documents for the proposed three new Intermediate Class Vessels. The assessment will be based on whether the specifications have incorporated a fuel efficiency target and have addressed the major concerns of ferry users regarding comfort and reliability of the new vessels in adverse weather conditions. Based on BC Ferries' application to the Ferry Commission for approval, the new vessels are to be designed such that there will be no additional cancellations due to adverse weather conditions as has been experienced by the existing vessels operating on Routes 9 and 17.

This report is divided into 2 parts dealing with the (a) fuel efficiency and (b) the probability of spray on deck. It is based on information provided to 3GA by BCFS.

2 FUEL EFFICIENCY TARGETS

The concept developed with regards to a fuel efficiency target is to define an overall annual percentage (6.5%) improvement in fuel usage. This requires a base line value against which to measure the improvement. The annual fuel consumption of the current vessel(s) is known. However in order to determine the achieved fuel consumption of the proponent's new design vessel and to relate that to a contractually measureable target, the actual historical fuel consumption numbers were "modeled" in a typical annual operational profile, i.e. the percentage of time the vessel spends in different modes such as transit and in dock etc have been established by BCFS. This matrix of conditions provides a speed and power target for actual measurements to be undertaken at discrete events and conditions and then to related those back to the annual consumption.

The matrix and target values have been validated by BCFS and through independent review as being representative of the actual consumption profile.

The contract calls for the builder to prove the fuel reduction achieved in 2 parts;

Firstly the specific power to fuel consumption of the engines is to be demonstrated as achieving the design values that the builder has assumed in his ship design development. Actual engine specific fuel consumption is beyond the design control of the ship builder but is to be guaranteed by the engine supplier.

Secondly the shipbuilder is to demonstrate by specific trials and through instrumentation that the speed and power and fuel consumption at specific conditions are achieved and therefrom, by translation to the operational matrix, are likely to achieve the fuel reduction target reduction from the base line operational matrix.

The contract contains liquidated damage clauses that will return cash to the company in the event that these measures do not demonstrate that the vessel achieved the 6.5% fuel reduction target.

Within the body of the proponent's response the designer has made performance claims that exceed the target reduction values when estimates are derived by generally accepted numerical simulations. This provides a significant margin over the contractual performance demand and thus provides confidence in the final as built ship being able to demonstrate compliance.

It our opinion that the design data provided by the proponent and BCFS internal works provides sufficient review and simulation of the proponent's design to ensure that the design will achieve the target overall fuel consumption reduction. Furthermore the methodology and contractual measures invoked provide confidence in the end deliverable being able to achieve the target 6.5% reduction in fuel consumed.

3 WATER SPRAY ON THE CAR DECK

The concern that an open deck vessel would cause vehicles on the car deck to be exposed to sea spray was expressed in the consultation process. This concern was translated into a performance objective that was included in the design brief for the build proponents to address during the bidding phase, viz: “vehicle deck(s) are free from sea spray 95 % of the time in normal operating conditions up to Beaufort Sea State 5”.

This is considered to be a reasonable objective that can be achieved by the inclusion in the design of high sided bulwarks and bow visors that will effectively shelter the car deck from sea water spray impacting on the occupants and vehicles on the deck. The level of protection offered will be dependent on the height of these sides.

A variety of difference evaluations and methodologies were provided in the responses received from shipyards. These included simple comparisons of vessel shape and visor configuration with existing, and presumed to be acceptable, open deck ferry vessels operating on similar types of voyages in Europe to semi empirical analyses techniques based on scientific research.

The selected proponents design actually carries a significant number of its cars in an enclosed lower deck and the design includes high bulwarks and visor to protect the remainder and the methodologies described above were applied internally within BCFS.

To review the design constraint and make some internal verification of the spray phenomena as it applies to the selected vessel, BCFS has conducted a 2 part analysis exercise whereby;

Part 1 is a review of the probability of occurrence of weather conditions that prevail in the 95% time frame. This review was taken from recorded data at 2 weather stations in the region, Sentry Shoal and Halibut Bank. These data revealed that the probability of occurrence of wind condition of the Beaufort 6 level and greater occur annually at the 6.5% and 3.3% of time levels, i.e. wind does not exceed 93.5% and 96.7% of the time at the wave buoys considered.

Given that spray on deck in the situation under consideration can be attributed to wind carrying the water off breaking waves and ship impact events then considering the design wind condition to be Beaufort 5 wind condition is reasonable.

The analytical approach to determination of spray is generally associated with the icing of ships as spray is the principle cause of super structure icing and loss of stability in ships. While icing is not a consideration for the service condition under consideration here, the analysis methodology to assess the amount of water that becomes airborne is relevant. BCFS has adopted the methodology to determine the level of spray that can be expected in the design wind condition as described by Zakrzewski, W.P. (Icing of Ships. Part I: Splashing a Ship with Spray, NOAA Technical Memorandum, USA, 1986).

The Zakrzewski methodology is a semi empirical approach validated by deep sea ship trials. It creates values for the likely mass transfer of water in the air at varying heights above the water based on wind speed and the ship's speed and heading into the wind. When applied to the ferry design the mass transfer of water in air at 9 meters (the approximate height of bow visor / bulwarks above the water line) is negligible at the wind speeds around Beaufort 6 i.e. it is in the order of 0.002 kg/meter³. (At these heights above deck the data indicated very small numbers).

To put these numbers into perspective, the mass content of water droplets in air when it is dense fog is $0.00005 \text{ kg/meter}^3$ and a heavy rain fall is approximately 0.02 kg/meter^3 . That is to say that the wetness of the air at the visor level is an order of magnitude less than if it were raining.

It is our opinion that the selected proponent's design has adequately mitigated the concern over spray water on the car deck firstly by locating a large portion of the vehicles carried on the vessel in a fully covered garage deck and secondly, by including bulwarks and visors of sufficient height to effectively shelter the open car deck from the spray that is likely to be encountered 95% of the time.