



**ART ANDERSON ASSOCIATES**

**TECHNICAL MEMORANDUM**

20 October 2005

Phil Logan  
President-WMCA  
1742 Morningtide Ct.  
Anchorage, AK 99501

Subj.: Storm Loss & Restoration at Cliffside Marina, Whittier, AK

Dear Mr. Logan,

Art Anderson Associates is pleased to submit this report regarding losses and restoration for the Whittier Marina Condominium Association, Inc. (WMCA), Cliffside Marina, in Whittier, Alaska. It is our understanding that the marina opened in January 2005, sustained minor storm damage both during construction and through-out the winter of 2005 which culminated with severe storm damage on March 10, 2005. I visited the facility on July 27th and 28th, 2005 to assess the extent of storm damage and provide engineering recommendations for actions that should be taken to restore the facility to a like new condition. The scope of our engineering investigation and study also includes recommendations to mitigate risk of further loss.

Background:

The extent of the constructed harbor protection system for the Cliffside Marina was limited to the cruise ship terminal facility which provides partial sheltering of the marina for winds out of the east and northeast. The harbor protection system developed to provide storm protection for the boat moorage basin at the time the marina was certified for occupancy, was inadequate to protect the marina from routine weather events from the west which allowed significant amounts of ice (freezing spray and wave wash) to accumulate atop floats, and the winter weather events from the northeast which

ultimately rendered approximately one quarter of the marina as unusable for its intended purposes.

The March 2005 storm impacted the entire marina facility, with catastrophic failures along the M and N-docks, local failures of the west end of the headwalk, substantial damage to the most northern portions of L-dock, and visible wear and tear damage and/or impacts to the eastern portions of the headwalk and K and J-docks.

The lack of an adequate marina breakwater protection system to defend the marina from wind generated waves, has resulted in other unintended operational conditions that jeopardize the safety of the facility, the facility operators, personal property (e.g. yachts), and marina owners. Review of the photographs taken earlier in the winter of 2005 document that ice build up atop N and north end of K-dock was so severe that partial submergence occurred. Westerly winds combined with below freezing temperatures produce spray and wave overtopping that ultimately freezes. Ice build-up overloads the buoyancy capacity of the float system causing severe risk of submerging the docks. It was verbally stated to me during the site visit and investigation that the icing condition had been reported to the design engineer-of-record. Submergence of the docks would probably present only a nominal risk of damage to the pontoons, it would however, represent a substantial risk to the electrical power systems and components. Furthermore, the ice build-up condition is uncontrolled and therefore presents substantial risk to the pontoons and hardware as well, especially when subjected to the dynamic sea states of a marginally protected marina.

#### Purpose:

The purpose of this technical memorandum is: a) Identify the scope of repairs to the marina floats and infrastructures to restore it to a condition similar to its pre-storm condition. This task item will allow the marina owner's association to work with one or more contractors to determine the cost to restore the marina to its "as new" pre-storm status; b) Recommend action to reduce further losses due to the damaged condition of the facility, i.e. mitigate the risks of further property damage due to the compromised integrity of the facility; and c) Identify activity that must be completed to reduce the risk of recurrence of a similar incident.

#### Discussion:

The repair actions that will be necessary to restore the marina to its pre-storm status are provided in the recommendations section of the body of this report and Appendix A. Art Anderson Associates recommends that repaired and/or remanufactured replacement structure and hardware be installed after an adequate harbor protection system is constructed and installed, that would reduce the risk of storm damage recurrence to be within an acceptable standard. The determination and establishment of the appropriate harbor protection standard that should be adopted for the Cliffside Marina are beyond the scope of our professional services agreement. However, the standard for level of harbor protection should consider the storm condition recurrence interval, the design limits for the marina floats and hardware, the aesthetic consideration of the sea state conditions within the marina (i.e., the limit of wave conditions which are tolerable to the marina slip owners), and the insurability of the marina to allow purchase of insurance for continued operations.

Art Anderson Associates has not assessed the climatology of Whittier, AK or Cliffside Marina, and therefore cannot provide detailed conclusions or recommendations for the harbor protection system that needs to be implemented at Cliffside Marina prior to restoring the marina to a like new condition. However, we can provide general engineering judgment comments that are extensions of our substantial professional practice in marina engineering design, hydrodynamic analysis of floating bodies subjected to weather events, and research and development of multi-body offshore platforms subjected to harsh or extended sea-states.

Harmonics and dynamic resonance are typically the controlling design parameters for large floating structures such as marina wave attenuators, floating causeways, or floating bridges. Any floating body has a natural frequency which is a function of its mass properties and geometries. Harmonics or resonance can occur when the body is subjected to a wave environment that excites its natural frequency. The hydrodynamic response of the floating structure is influenced by a complex set of parameters including wave characteristics, currents, multi-body interactions, moorings, site bathymetry, wave dispersion characteristics and numerous other variables.

A structure that serves as wave attenuator when subjected to a particular given wave pattern may actually cease to attenuate waves and in turn behave like a wave generator when subjected to a different wave pattern that excites the structure to induce harmonic resonance. The physical phenomena of harmonics and resonance is always a primary concern in a wave environment. In the case of the wave conditions that are encountered at Cliffside Marina, understanding and predicting the hydrodynamic interaction is further complicated by the non-linearity of the interaction. Non-linear interaction is a critical consideration for large amplitude wave environments, and should be considered when designing or analyzing a proposed breakwater for Cliffside.

It is our understanding the engineer-of-record has proposed a floating wave attenuator to be constructed of steel pipe and timber. Although we have no comment on the suitability of the proposed structure for the intended application, we were asked to provide commentary on the most economical way to proceed with the overall restoration of Cliffside Marina. Assuming WMCA has confidence in the technical competency of the engineer-of-record, we would note that proceeding under the engineering guidance of the original engineer-of-record would offer the economy that is inherent with their ownership of the baseline engineering marina data. Any other engineer would likely not proceed with developing solutions to correct the marina problems without first redeveloping that baseline engineering data since a new engineer-of-record would essentially inherit the risk associated with the original baseline engineering data. Moreover, state law may preclude any such re-use of baseline engineering data, depending on the type of data and how it is used. We therefore conclude that there may be substantial economies or savings by proceeding with the original engineer-of-record vice hiring an independent new engineer to provide engineering guidance for restoration of the facility. However, the economies of continuing with the original engineer-of-record should be weighed against the value of hiring an independent engineer that may bring a fresh approach to solving the problems, as well as a healthy caution to avoid duplicating inappropriate engineering judgments that most likely contributed to current problems at Cliffside Marina.

### On-Going Problems:

I was notified via telephone that a storm on September 27, 2005 caused additional damage to the L dock walkway near its northern end. We anticipate that problems will continue to exacerbate until an adequate harbor protection system is put into service. Moreover, any actions to reduce risk of further damage will not ensure safety of the facility or property, until an adequate harbor protection system is installed. The recommendations provided herein to reduce risk of further damage (prior to installation of a breakwater) are considered to be marginal to poor, and are offered as actions to help minimize further loss until a permanent solution can be implemented. No warrantee is offered or implied that these actions will reduce the risk of further damage to an acceptable level, rather it is hoped that such actions may partially reduce the risk of catastrophic damage to the facility or loss of property such as the sinking of yachts. We are concerned that storm compromised floats at the western end of the marina are at a high risk of becoming adrift during a storm. An unsecured float adrift within the marina presents a high risk of substantially damaging or even sinking one or more yachts in addition to damage it could cause to the facility. Adrift floats outside the marina in open water present a safety hazard to vessels at sea and property or vessels at or near shore in the local area.

### Recommendations:

- A. Restore Marina to the Pre-Loss Status. The majority of the modular floats that make-up the marina facility did not display any visual signs of damage. Several floats sustained minor damage. The floats with minor damage are considered "repairable" to like new condition using construction repair methods similar to techniques commonly used to repair defects such as concrete spawls that occur during manufacturing. A total of 18 float modules are considered damaged beyond the point of being restored to a "like new" condition and should therefore be surplused and replaced.

The hardware that makes up the joints between the various float modules appear to have been potentially impacted throughout the marina, with obvious problems west of K-dock. Protected areas of the marina including K and J-docks and adjoining head walkway do not appear to have been damaged, but may have had the hinge assembly connections loosened by the storm. Consequently all the joint assemblies west of K-dock should have all their fasteners tightened and re-torqued to original installation specifications. Several joint assemblies (west of J and K-docks) need to be refurbished with new fasteners, new rubber bushings, or other sub-assembly hardware. A total of 23 joint assemblies will need to be completely replaced. In addition, joint assembly at K-dock and east of K-dock should be sampled for conformance with original design torque.

All piling along the N and M-docks are considered to be high risk of having sustained soil interface failures. The pile bents at the northern end of N-dock appear to have failed in uplift tension. These pile bents will require a detailed geotechnical assessment, but may be assumed to need to be pulled and replaced with longer piles of a large diameter. We recommend for the purpose of cost estimating that the replacement steel tonnage be increased by 50% over the steel tonnage for the original installation. This pile size increase is assumed

necessary to compensate for the compromised soil conditions that exist where the replacement piles will be driven.

We recommend a pile horizontal load test be conducted on a sample of the cantilever mooring piles in accordance with ASTM standards. The tests are needed to assess the installed pilings capacity to meet the original installation design load condition. Load testing 3 of the most northern M dock piles should provide a reasonable sample to determine suitability of the installed pile to meet the required design loads. Expand testing if any tested pile fails its test criteria. Alternately, if the trend is sub-standard pile load capacity, consider replacing all piles at N and M docks with larger and longer piles.

The western corner intersecting TRAN1; CONN1 floats and northeast corner of the Day Cruise Dock were reported to be grounding during periods of minus tide. The highway revetment (i.e., the rip rap armoring of the slope along the shoreline) appears to have been compromised by the storm waves, and resulted in a rock slump. The tidal conditions at the time of my site visit prevented any direct observation of the grounding problems. Likewise I was not able to observe the extent of the slumping condition near the toe of the slopes at either location, but am concerned that any rocks that may have been washed under the floats in these locations poses a serious threat to floats during low tide conditions.

This grounding condition should be corrected to avoid future complications. The problems areas should be dredged to the original design depth as specified by the engineer-of-record on the original marina construction plans. Dredging can occur while the marina floats are removed prior to replacement with new floats. The Day Cruise Dock will need to be temporarily relocated while dredging occurs.

Refer to Appendix A for a detailed accounting of recommended repairs.

- B. Interim actions recommended to Reduce Further Losses. The M and N docks along with the head walkway west of L dock should be temporarily disassembled and stored uplands until an adequate breakwater is installed. An interim float or other assembly developed to minimize the icing (that is caused by the westerly winds) is needed to protect the marina facility and yachts from an icing hazard. Details of the interim float or similar structure shall be engineered by a qualified designer prior to installation. Electrical circuits that are physically located on or near N and M-docks such as the transformer located on the headwalk float, mark "CONN-5" (see float shop drawings), should be isolated and de-energized.
- C. Action Required to Reduce Risk of Recurrence. A wave attenuator breakwater or other harbor protection system that will protect the harbor and defend against the adverse wind and wave conditions that occur at the site is essential to reduce the risk of reoccurring damage and minimizing future structural and maintenance problems at Cliffside Marina.

A typical engineering planning and design sequence for developing a reliable solution for the conditions at Cliffside Marina would include a climatology study. The climatology study would typically review the most reliable historical weather data that is available near the site. The weather data would be reduced using

statistical analysis to hind-cast wind and wave storm conditions that should be used as design criteria for the marina.

The next step in the engineering planning and design sequence would be numerical wave modeling of the site. The wind and wave design criteria developed during the climatology study would be input data for the numerical wave modeling. The wave modeling step would characterize and quantify the wind and wave condition that should be anticipated at the site. The wave modeling step would also normally be used to establish the criteria for the coefficient of transmission ( $K_t$ ) that should be used in the design of a wave attenuator or other harbor protection system.

The wave model would typically be updated or modified to add the wave attenuator(s) and re-run to predict the conditions within the boat basin area of the marina facility. Several interactions of adjusting design elements of the wave attenuator system may be required to converge on an engineering solution that provides the appropriate wind and wave protection performance from weather events.

The optimization for economy typically occurs in the final two stages of the engineering process. There are numerous proprietary products and design concepts that have been developed to provide wave attenuation for boat harbors. The primary feature of many of the products is economy, although if they do not perform in a manner that provides the intended level of harbor protection, the product becomes more of a liability than an asset. Therefore careful evaluation of any proposed harbor protection structure is a crucial next step (or concurrent step accomplished in parallel with earlier described engineering activities). Physical modeling of a proposed harbor protection structure is typically considered since this step provides opportunities to optimize design and performance prior to fabricating a structure for installation on site. Once the design parameters of the proposed structure have been developed through the process and sequence described above, a detailed hydrodynamic model of the proposed structure should be developed to assess the structural loads that will develop in the moorings and structure in its service condition. This step is used to optimize the number of piles, dolphins, or anchors used to moor the structure, as well as provide the global design loads for the structure that must be considered in the final design of the harbor protection structure.

The engineering fees associated with competently completing the engineering planning and design steps outlined in this section would typically range from \$350 thousand to \$450 thousand for a site like Cliffside Marina. This excludes final engineering design and construction document which would typically be in the range of 10 to 15% of the probable construction cost.

**Summary:** The problems at Cliffside Marina are complex and will not be fully stabilized until an adequate harbor protection system is in service to protect the boat basin from weather events.

The information presented in this reports should a) assist WMCA in working with a contractor to establish the cost to restore Cliffside Marina to its pre-storm condition; b) identify interim actions to reduce further loss, and c) provide guidance for long term stabilization of the Cliffside Marina facility.

Art Anderson Associates appreciates this opportunity to assist WMCA and would welcome the future opportunity to implement the engineering planning and design activities described in this report. Please contact me directly if you have any questions or concerns with the contents of the report.

Respectfully,



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VP, Facilities Engineering & Design

This document prepared under the direct supervision and assistance of:

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Enclosures: Appendix A – 4 pages



ART ANDERSON ASSOCIATES

APPENDIX A

October 20, 2005

RESTORE MARINA TO THE PRE-LOSS CONDITION

Note:

1. All mark designations refer to Shoreside Construction marina float shop drawings dated 06/28/04.
2. Disassemble hinge connection assembly; replace all damaged or worn parts, fasteners and rods. Restore joint and torque to manufactures recommended specifications.

Location	Mark #	Recommended Action	Comments
N-Dock	TRAN-1	<ul style="list-style-type: none"><li>• Replace float assembly</li><li>• Replace hinge assembly at TRAN-1/CONN-1 joint</li></ul>	Float has significant concrete spawls at threaded inserts which renders float difficult to restore to pre-storm condition.
	TRAN-2	<ul style="list-style-type: none"><li>• Replace rub rails Marks B-77 and B-1A</li><li>• See Note 2</li></ul>	Float appears to be in good condition.
	TRAN-3	<ul style="list-style-type: none"><li>• Replace hinge assembly at TRAN-3/TRAN-4 joint</li></ul>	Float appears to be in good condition.
	TRAN-4	<ul style="list-style-type: none"><li>• Replace hinge assembly at TRAN-4/TRAN-5 joint</li><li>• Replace rub rails Marks B-1, B-1A</li></ul>	Float has significant concrete spawls at threaded inserts which renders float difficult to restore to pre-storm condition.
	TRAN-5	<ul style="list-style-type: none"><li>• Replace float assembly</li><li>• Replace hinge assembly at both ends</li></ul>	Float has significant concrete spawls at threaded inserts which renders float difficult to restore to pre-storm condition.
	TRAN-6	<ul style="list-style-type: none"><li>• Replace all assemblies</li></ul>	Float was removed from site.

<b>Location</b>	<b>Mark #</b>	<b>Recommended Action</b>	<b>Comments</b>
Headwalk	CONN-1 (Headwalk Float)	<ul style="list-style-type: none"> <li>• Replace float assembly</li> <li>• Replace hinge assembly at both ends</li> </ul>	Float has significant concrete spawls at threaded inserts which renders float difficult to restore to pre-storm condition.
	CONN-2 (Headwalk Float)	<ul style="list-style-type: none"> <li>• Replace float assembly</li> <li>• Replace hinge assembly at both ends</li> </ul>	Float has spawls at joint anchorage embeds.
	CONN-3 (Headwalk Float)	<ul style="list-style-type: none"> <li>• Replace float assembly</li> <li>• Replace hinge assembly at both ends</li> </ul>	Float has spawls at joint anchorage embeds.
	CONN-4 (Headwalk Float)	<ul style="list-style-type: none"> <li>• Replace rub rails Marks B-65A &amp; B-65</li> <li>• Rework hinge assembly at CONN-4/CONN-5 joint – See Note 2</li> </ul>	Float appears to be in good condition.
	CONN-5 (Headwalk Float)	<ul style="list-style-type: none"> <li>• Replace hinge assembly at M-Dock joint</li> </ul>	Float appears to be in good condition.
	CONN-6 & CONN-7 (Headwalk Floats)	<ul style="list-style-type: none"> <li>• Further assessment required by contractor; float trim is high at CONN-6/CONN-7 joint</li> </ul>	Inspect for below waterline damage or need to ballast
	CONN-7 thru CONN-14	<ul style="list-style-type: none"> <li>• Re-torque hinge fasteners</li> </ul>	Several joint fasteners appear loose
	CONN-14 thru Pumpout-1	<ul style="list-style-type: none"> <li>• Check hinge fasteners at CONN-14 for conformance with installation torque specifications</li> </ul>	No further action required if CONN-14 torques are good; otherwise expand rework of joints until assemblies meet specifications.
M-Dock Walkway	M-1 (Float)	<ul style="list-style-type: none"> <li>• Replace hinge assembly at both ends</li> <li>• Replace all thru rods</li> </ul>	Joints severely degraded hinge assemblies; several rods appear to have yielded
	M-2 (Float)	<ul style="list-style-type: none"> <li>• Replace hinge assembly at both ends</li> <li>• Replace/rebuild finger connection hinge assemblies on both sides</li> <li>• Replace all thru rods</li> </ul>	Finger hinge assembly severely degraded on walkway side; sub-assembly appears good on finger side; several rods appear to have yielded.

Location	Mark #	Recommended Action	Comments
M-Dock Walkway (con't)	M-3 (Float)	<ul style="list-style-type: none"> <li>Replace hinge assembly at both ends</li> <li>Replace/rebuild finger connection hinge assemblies on both sides</li> <li>Replace all thru rods</li> </ul>	Finger hinge assembly severely degraded in walkway side; appears good on finger side; several rods appear to have yielded.
	M-4 thru M-6 (Float)	<ul style="list-style-type: none"> <li>Replace float assemblies</li> </ul>	Re-galvanize pile and test piles per body of report.
M-Dock Fingers Note naming convention: East odd #'s; west – even with lowest at headwalk	M-Finger1	<ul style="list-style-type: none"> <li>Patch spawl at end per manufacturers standard repair requirements</li> </ul>	Spawl is ~7" x 26" X depth of insert, centered at end of float
	M-Finger2	<ul style="list-style-type: none"> <li>N/A</li> </ul>	Appears fine
	M-Finger3	<ul style="list-style-type: none"> <li>N/A</li> </ul>	Appears fine
	M-Finger4	<ul style="list-style-type: none"> <li>N/A</li> </ul>	Appears fine
	M-Finger 5 thru Finger 10	<ul style="list-style-type: none"> <li>Surplus existing floats and replace with new</li> </ul>	Severely damaged floats are stored upland
L-Dock Walkway	L-1 thru L-5 (Floats)	<ul style="list-style-type: none"> <li>Rework all hinge assemblies for end and finger joints – See Note 2</li> <li>Replace damaged and worn parts</li> </ul>	Some joints appear to have excessive wear at rubber bushings; replace where this occurs
	L-6 (Float)	<ul style="list-style-type: none"> <li>Replace float assembly</li> </ul>	Numerous spawls at finger connections
L-Dock Fingers	Side Fingers	<ul style="list-style-type: none"> <li>Rework hinge joints</li> <li>Replace thru rods on north half of walkway</li> </ul>	No visible signs of damage to floats
	End Fingers Right & Left	<ul style="list-style-type: none"> <li>Replace finger assemblies</li> </ul>	Concrete failure at right finger cleat (spawling); hoop failures at ends of right and left fingers
K & J Docks	ALL	<ul style="list-style-type: none"> <li>Sample inspect connection assemblies per body of report</li> </ul>	This portion of the marina does not appear to be damaged
General: At N-Dock, M-Dock, & Northern half of L-Dock	Thru Rods for Pile Hoops	<ul style="list-style-type: none"> <li>Replace rods and re-torque/restore to original design specs</li> </ul>	Rods may have yielded.
Western Corner	TRAN-1/CONN-1	<ul style="list-style-type: none"> <li>Dredge to design depth</li> </ul>	Floats grounding during minus tides

<b>Location</b>	<b>Mark #</b>	<b>Recommended Action</b>	<b>Comments</b>
Day Cruise Dock	N/A	<ul style="list-style-type: none"><li>• Dredge to design depth</li></ul>	Float grounding during minus tides