WAVE-INDUCED DELAYS IN CARGO TRANSFER AT VALDEZ MARINE TERMINAL – BERTH 4

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ABSTRACT

The Valdez Marine Terminal on the south side of Port Valdez in Prince William Sound, Alaska, occasionally experiences extreme easterly winter winds that either render oil boom deployed around a moored tanker to be overtopped by waves or prevent the safe deployment of the boom on arrival of a tanker. Either contingency results in disruption of oil transfer with the threat of overwhelming storage capacity at the terminus of the trans-Alaska oil pipeline. Investigations of long-term wind data measured in Port Valdez, the east-west-oriented fjord on which the Valdez Marine Terminal is located, revealed that easterly winds on the south side by the terminal are typically stronger than on the north side where winds are recorded for public archives. Recorded wind data was not available on the south side of Port Valdez and installation of a recording anemometer in the vicinity of the terminal is recommended. Alternatives investigated to reduce oil transfer disruptions during extreme easterly winds include positioning an ocean tug upwind (with or without a barge) as a wave barrier, temporary and permanent deployment of harbor-type floating breakwater, and deployment upwind of an extra oil boom as a partial wave barrier. Deployment of harbor-type breakwater is not recommended due to risk of rigid units and attached mooring lines accidentally floating downwind against the operational oil boom, the tanker, and the terminal structure. Operational tests of a tug and barge dynamically positioned upwind and deployment of an additional oil boom upwind are recommended. The worst-case scenario of a Trans-Alaska Pipeline shut-down can be avoided by assuring that sufficient storage capacity remains in service at VMT, such that cessation of oil transfer to tankers in severe weather can be occasionally accommodated. The measures recommended above will also serve in the undesirable event that a spill accidentally occurs at the berth and severe weather arises when containment depends on the effectiveness of the boom surrounding the tanker and berth.

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MARIA KARTEZHNIKOVA[1] , *ORSON SMITH*[2], *PETER OLSSON*[3]

INTRODUCTION

The Prince William Sound Regional Citizens Advisory Council (PWSRCAC), based in Valdez, Alaska, is an independent non-profit corporation formed following the 1989 Exxon Valdez oil spill and the Oil Pollution Act of 1990 to promote environmentally safe operation of the Valdez Marine Terminal (VMT), operated by Alyeska Pipeline Service Company, and the oil tankers that use it. The PWSRCAC is composed of volunteer representatives from communities and interest groups in Prince William Sound, Kodiak Island, lower Cook Inlet, and points between where oil from the Exxon Valdez oil spill was found. The Council employs a full-time staff, based in Anchorage and Valdez. The Port Operations and Vessel Traffic Systems (POVTS) Committee of the PWSRCAC monitors tanker operations in Prince William Sound, including at the tanker loading berths of the VMT. Veteran POVTS Committee members were aware for some years of extreme historical wind events that had caused VMT operators to halt transfer of oil to ships for fear that oil accidentally spilled would not be contained by the routinely deployed boom surrounding the ship.

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This report is a preliminary investigation of wave-related difficulties in boom deployment and effectiveness at Berth 4 of the VMT. The report is, in part, an academic exercise for the first author of this report as a graduate student enrolled in the University of Alaska Anchorage (UAA) course titled “CE A675Design of Ports and Harbors.” The second author is the instructor of that course and a member of the PWSRCAC POVTS Committee. The third author is the Alaska State Climatologist at the UAA’s Environment and Natural Resources Institute, who provided expert opinion on wind climate and origins of extreme wind events at site. None of the authors were compensated for this work. PWSRCAC support was limited to travel expenses for a site visit on 11 October 2012. Copies of related correspondence are included in the Appendix B.

PROBLEM IDENTIFICATION

The VMT was designed for loading crude oil onto tankers and for storing crude oil so that Alaska North Slope production and oil flow in the Trans Alaskan Pipeline System (TAPS) can continue without impact from discontinuities of marine transportation. However, adverse weather conditions, particularly strong northeast winds, have caused tanker loading to be suspended for wave-related problems at Berth 4. The worst case scenario occurs when inclement weather and sea conditions persist and, without any transfer of oil to tankers, storage capacity is exceeded and flow in the entire TAPS must be halted. The following paragraphs summarize information obtained from PWSRCAC and Alyeska specialists, from site visit observations, and from facts on file.

VALDEZ MARINE TERMINAL

The VMT is located on the south side of the ice-free fjord named Port Valdez on the northeastern corner of Prince William Sound, Alaska (Figure 1).The City of Valdez is located on the opposite north side of Port Valdez. The VMT marks the end of the Trans-Alaska Pipeline System, TAPS (Figure 2). The Alyeska Pipeline Service Company operates the 800-mile (1,300 km) oil pipeline that extends from Prudhoe Bay on the Arctic Ocean to the Valdez Marine Terminal. The VMT has 18 storage tanks with overall holding capacity of approximately nine million barrels (Alyeska Pipeline Service Company, 2012). Not all of these tanks are presently kept in service, however.

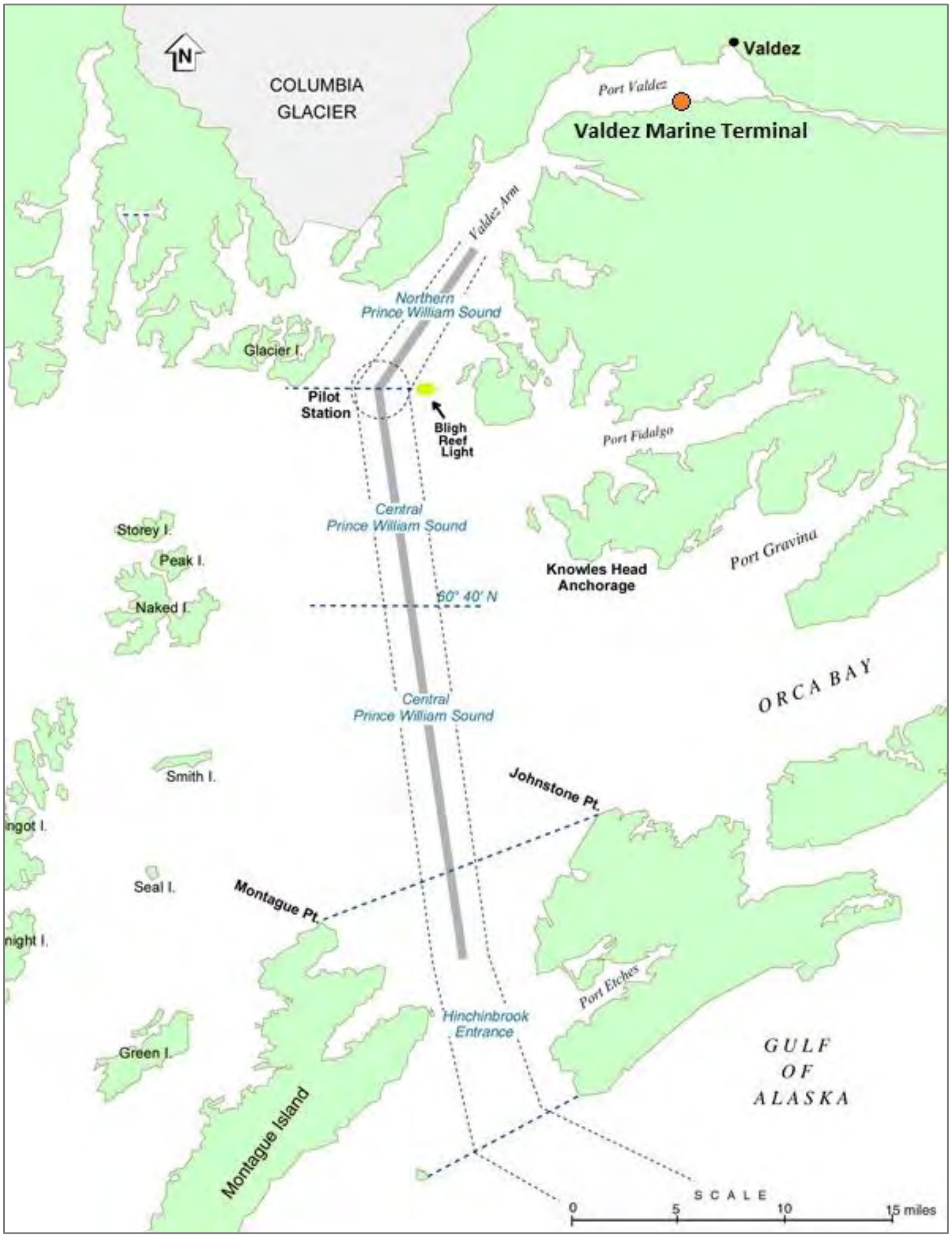

Figure 1. Location of VMT, Tanker Lanes, and Escort Zones in Prince William Sound (PWSRCAC, 2012)

Figure 2. The southern end of the 800 mile-long Trans Alaska Pipeline at Valdez Marine Terminal (photo by M. Kartezhnikova).

BERTHS

The VMT includes four tanker loading berths (Figure 3). Berth 1 is a floating platform and the rest (Berths 3, 4, and 5) are fixed liquid bulk terminals. No “Berth 2” was ever built. Berths 4 and 5 have been the primary loading berths since 1998 when they were fitted with vapor recovery arms to collect fugitive vapors released during tanker loading. Both berths have a loading capacity up to 110,000 bbl per hour (Alyeska Pipeline Service Company, 2012).

Figure 3. Aerial view of berths at Valdez Marine Terminal (Google Earth)

Berths 1 and 3 have no vapor control systems and are no longer used for crude oil loading. Berths 1 and 3 occasionally see service as temporary moorings for tugs and service vessels and once in a while for tankers waiting access to Berth 4 or 5. Fuel oil lines and crude and ballast headers at Berth 1 have been drained and isolated. Berth 3 can be returned to service in special situations with advance preparations. Berth 5 was not in service at the time of the site visit (October 2012), while it was undergoing maintenance. Water depth available is 90 feet at mean low water at Berths 3 and 4 and around 80 feet at Berth 5 (MXAK, 2010).

VMT CONTAINMENT BOOMS

Tankers loading crude oil at VMT must be surrounded by oil containment boom, according to regulation 18 AAC 75.025(b) administered by the Alaska Department of Environmental Conservation. Before transfer of crude oil to a tanker is initiated at either Berth 4 or 5, crews use small boats to completely encircle the berth and tanker with an oil boom (Figure 4). Two different types of boom are presently used at VMT: Ro-Boom 1500 and NOFI 800S. Ro-Boom 1500, produced by DESMI Ro-Clean, has inflatable chambers with a freeboard of 20 inches and an overall depth of approximately 59 inches. The buoyancy chamber horizontal length is 177 inches. The boom is fabricated of heavy duty neoprene rubber with stainless steel fittings and a hot galvanized steel ballast/tension chain with a breaking load of 200 kN (about 22.5 tons, see Figure 6). Internal fiberglass rods secured with stainless steel brackets (Figure 5) ensure optimum skirt profile. The manufacturer claims that Ro-Boom 1500 is effective in waves up to 3.5 meters (11.5 ft) height (DESMI, 2011).

Figure 4. Tanker at VMT surrounded by oil containment boom (PWSRCAC photo)

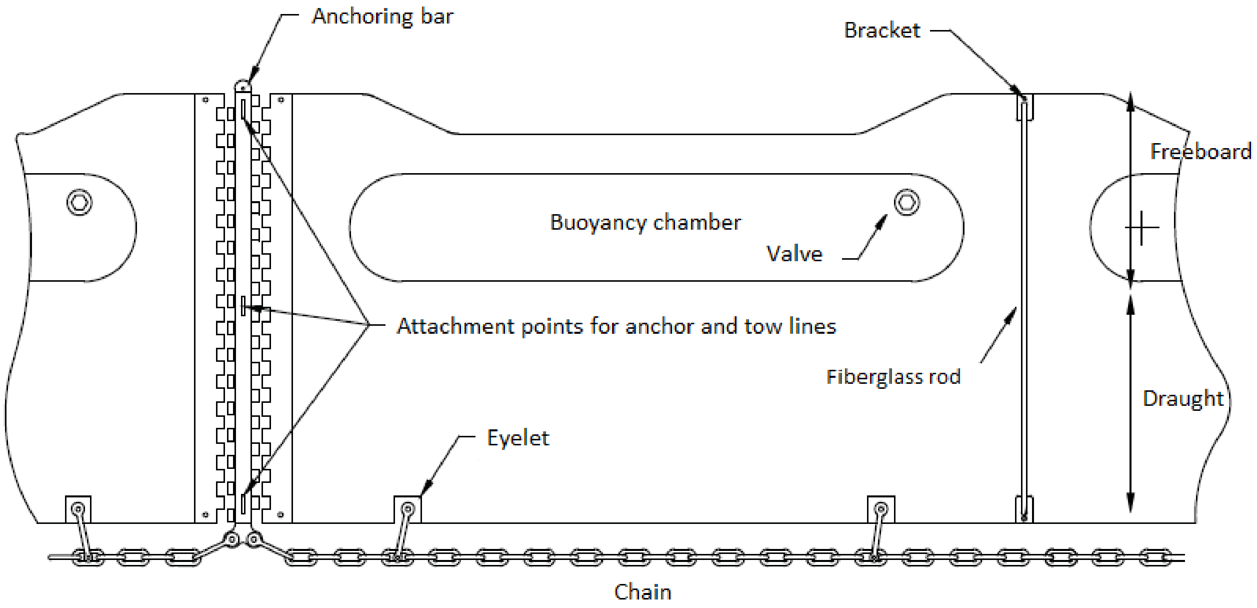

Figure 5. Schematic of Ro-Boom 1500 chamber section (side view, not to scale)

Figure 6. Deflated Ro-Boom 1500 (photo by M. Kartezhnikova)

The NOFI 800S, produced by NOFI Tromsø AS, was purchased by Alyeska for features that accommodate service at the VMT during winter season (Figure 7). NOFI 800S is made of high strength synthetic materials that are resistant to degradation from oil and winter exposure. Heavy duty PU/PVC coated polyester is used for the flotation tube and skirt, and Dyneema rope with breaking strength of 240 kN (about 27 tons) is used as the bottom tension line (Figure 8). NOFI 800S has freeboard of 31.5 inches, and the skirt depth of 37.4 inches. Total depth of the inflated boom is 84.25 inches, including a permeable "feather net" that hangs below the impermeable skirt. The manufacturer claims that this boom can withstand significant wave heights of 6 meters (20 ft) and remain effective in waves up to 3.5 meters (11.5 ft) when deployed in open ocean conditions (NOFI, 2009).

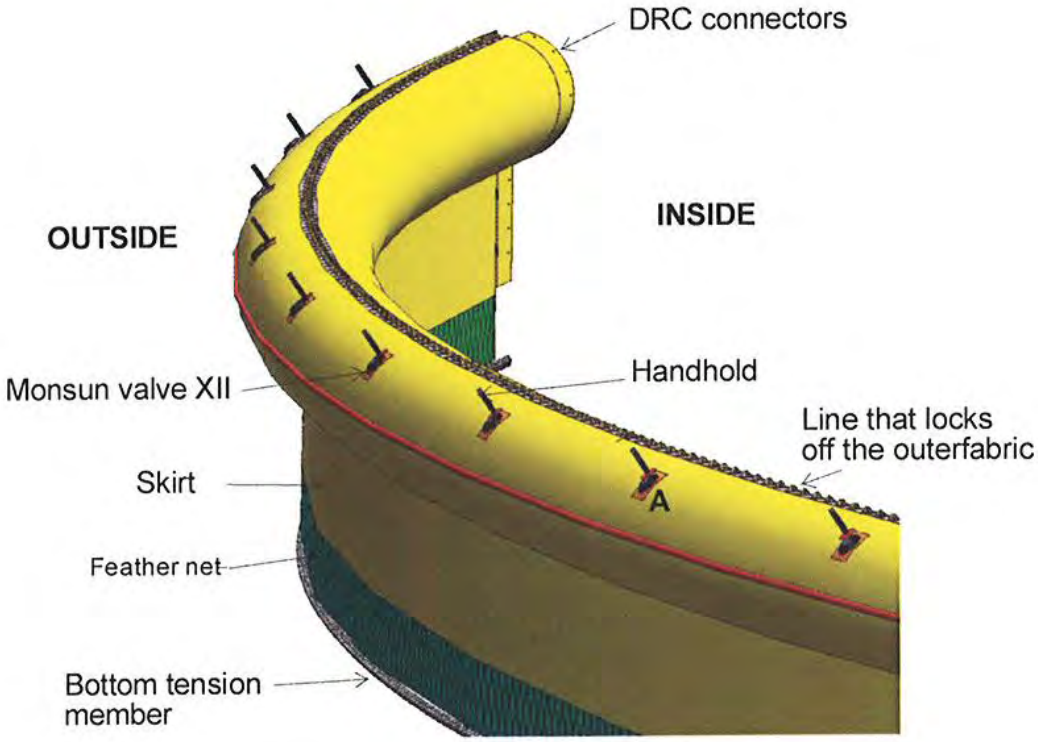

Figure 7. Schematic view of inflated NOFI 800S, not to scale (NOFI, 2009)

Ro-Boom 1500 is deployed by Alyeska at the VMT berths in summer and NOFI 800S in winter. The winter service boom is inflated and launched in early fall and changed out in the spring for the summer service boom. Booms are moored inshore near the berths when not anchored to surround a loading vessel. Small boats tow the booms into place around each tanker that arrives and retrieve the booms when product transfer is complete and the ship is ready to depart. Booms are cleaned and serviced prior to storage for their off-duty season. For more details regarding VMT booms, see Appendix A.

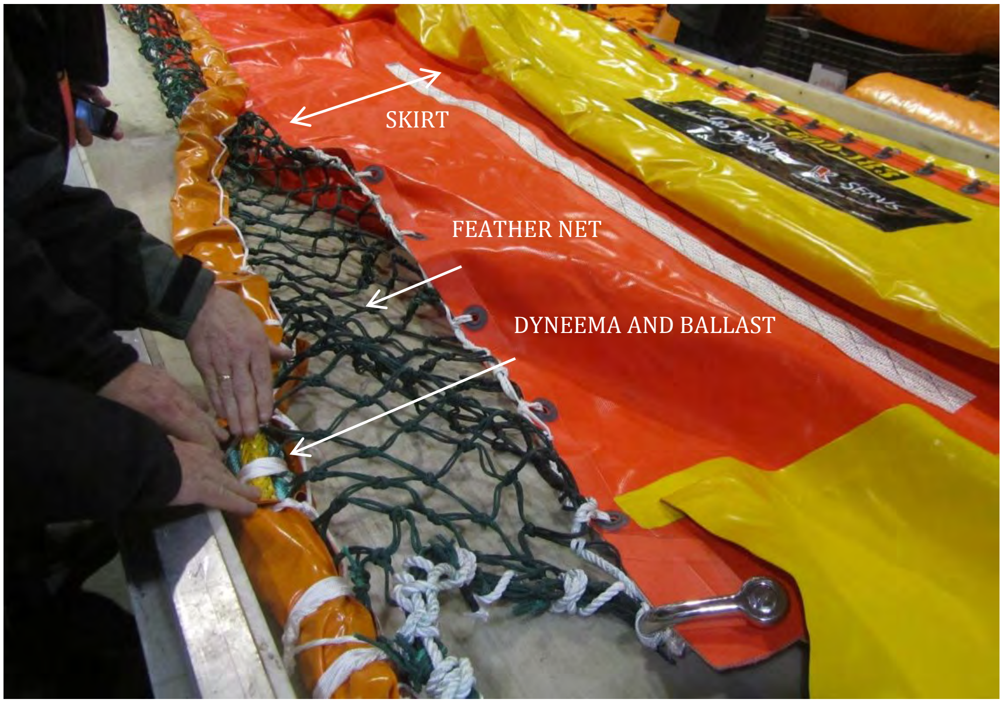

Figure 8. Deflated NOFI 800S (photo by M. Kartezhnikova, 2012)

BOOM DEPLOYMENT AND CONTINGENCY PROCEDURES

Alyeska's Ship Escort/Response Vessel System (SERVS) element, created in 1989 to prevent oil spills and provide oil spill response and preparedness, is responsible for deployment, retrieval, and maintenance of oil booms at the VMT. SERVS also monitors vessel traffic in Prince William Sound and operates escort tugboats to guide tankers from the Gulf of Alaska through the Sound to the VMT and return.

The length of oil containment boom deployed to surround a tanker is approximately 2500 feet. Once the boom is inflated and launched, it stays in the water for its entire duty season. According to terminal operators, crews can deploy a boom in as little as 20 minutes in good weather conditions, including retrieval of lines attached to prepositioned anchors on the sea floor. Adverse weather conditions increase this time significantly and, at worst, preclude boom deployment altogether. Three different procedures have been developed by SERVS for boom deployment during adverse weather conditions, in order of complexity: winter service boom deployment (TACTIC VMT-AW-1), diversion boom deployment (TACTIC VMT-AW-2), and increased recovery of free oil (TACTIC VMT-AW-3).

Figure 9. Boom deployment vessels (to left) at the VMT small-boat harbor (photo by Orson Smith, 2012)

Four work boats (Figure 9) are dispatched for the deployment of the winter service boom. Each boat normally has two people on board, but a crew of 3 may be provided in extreme weather conditions. Positioning of diversion booms (approximately 2080 feet long per TACTIC VMT-AW-2) requires 2 work boats. TACTIC VMT-AW-3 involves the most personnel and equipment (Figure 10), since the procedure specifies that additional boom be placed downwind to divert oil escaping primary containment toward an oil spill skimmer vessel.

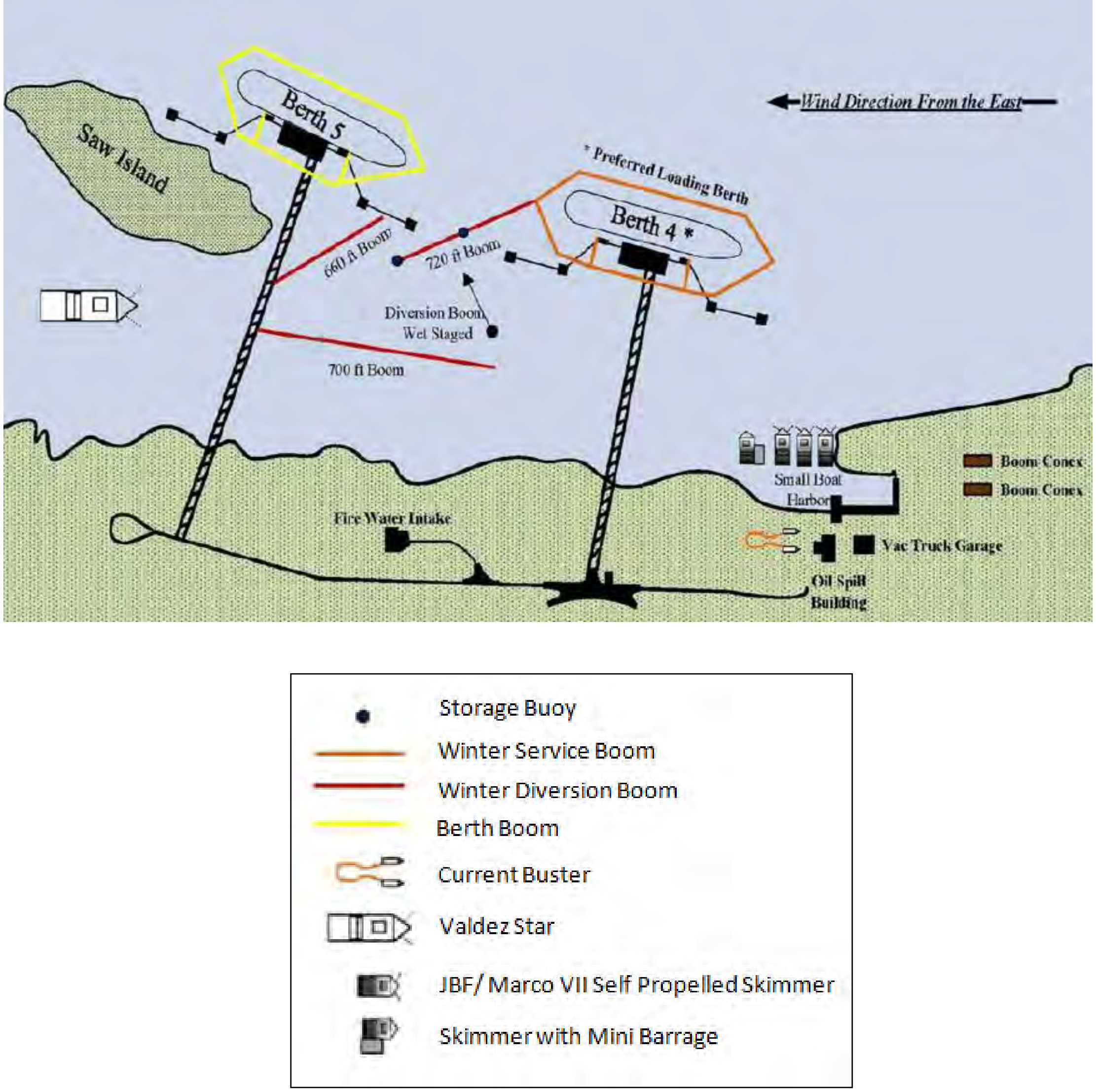

Figure 10. Adverse weather loading response tactic: TACTIC VMT-AW-3

“Weather Impacts & Response Capabilities on Transfer Operations”, the overarching SERVS operating procedure, specifies that the VMT Operations Supervisor and the tanker commander are jointly responsible for determining if weather conditions would affect the ability to safely conduct transfer operations. The VMT Operations Supervisor must be notified when the average wind speed at the berth exceeds 25 mph (20 knots). Transit of tankers in Port Valdez is prohibited for all tanker traffic when the wind speed exceeds 40 knots (46 mph, PWSRCAC 2012). The final decision to implement Adverse Weather Loading Tactics is made on the basis of the following factors, according to SERVS officials interviewed during the October 2012 site visit:

- Sustained wind speed at 30 knots or greater from the east/northeast
- Waves overtopping the boom (if already deployed)
- Integrity of the deployed boom
- Safety of vessel crews and other operating personnel to deploy, maintain, or retrieve the boom
- Remaining capacity in VMT crude oil storage tanks

Wind speed measurements applied for these decisions are observed by anemometers aboard vessels, including the tanker moored at the berth, and by anemometers on the terminal. None were equipped with means to record wind data, according to SERVS officials present during the October 2012 site visit. Incidents of extreme conditions are documented, however, and wind speed observations are noted in this documentation. “Average wind speeds” noted are apparently short term averages of subjective duration, perhaps only a few minutes, of winds sustained at or above the wind speed reported. Records of rise to a critical threshold, duration above that threshold, and fall of wind speed during an extreme event are not maintained.

SERVS adverse weather procedures are rigorously defined, but are invoked essentially through the expert judgment of supervisory personnel on duty at the VMT when adverse conditions appear, in consultation with Alaska Department of Environmental Conservation officials. All decisions are aimed foremost at prevention of an oil spill or at containment of a spill if one occurs in spite of precautions, and at protection of the surrounding marine environment. The decision to halt transfer of oil to a tanker at the berth is made in two different circumstances during extreme weather:

1. The boom is not deployed. In this situation, responsible personnel subjectively evaluate the dangers to be encountered by crews, vessels, and equipment while attempting to deploy a boom in high winds and waves. The severity of conditions may also call into question the effectiveness of a boom, even if it is successfully deployed.
2. The boom is deployed. This situation involves observation of the boom's integrity and its effectiveness as reduced by wave overtopping. Here also the safety of crews, vessels, and equipment is considered, since these resources may be required to leave shelter to maintain the boom or otherwise respond to a spill.

WIND AND WAVE CLIMATE IN PORT VALDEZ

Port Valdez is at the north end of Prince William Sound's Valdez Arm (aka "Valdez Narrows," Figure 11). While the Valdez Arm is roughly NE-SW in orientation, the long axis of Port Valdez is east to west about 22 km (12 nm) in length, with a north-south width of about 6 km (3.2 nm). Port Valdez is deeply incised, with terrain to the north and west quickly rising to over 1500 m (5000 ft), while terrain to the south exceeds 1000 m (3300 ft). Valdez Glacier Valley rises more gradually to the northeast toward the glacier terminus. The Lowe River valley to the southeast, the route followed by the Richardson Highway, is famously steep-sided as it gains elevation toward Thompson Pass.

CHANNELED FLOW IN PORT VALDEZ

The terrain configuration of Port Valdez provides for a large variety of terrain-induced and terrain-enhanced wind regimes. In particular, the stable near-surface atmosphere in Port Valdez is subject to channeled flow– typically in the form of density or drainage currents in the drainage bottoms. Given the small horizontal length scale and the large vertical scale of the topographic variation in Port Valdez, and the control this terrain exerts on near-surface winds, it is not at all uncommon for one location in Port Valdez to experience concurrent wind conditions quite different from another location just a few km (a mile or two) away.

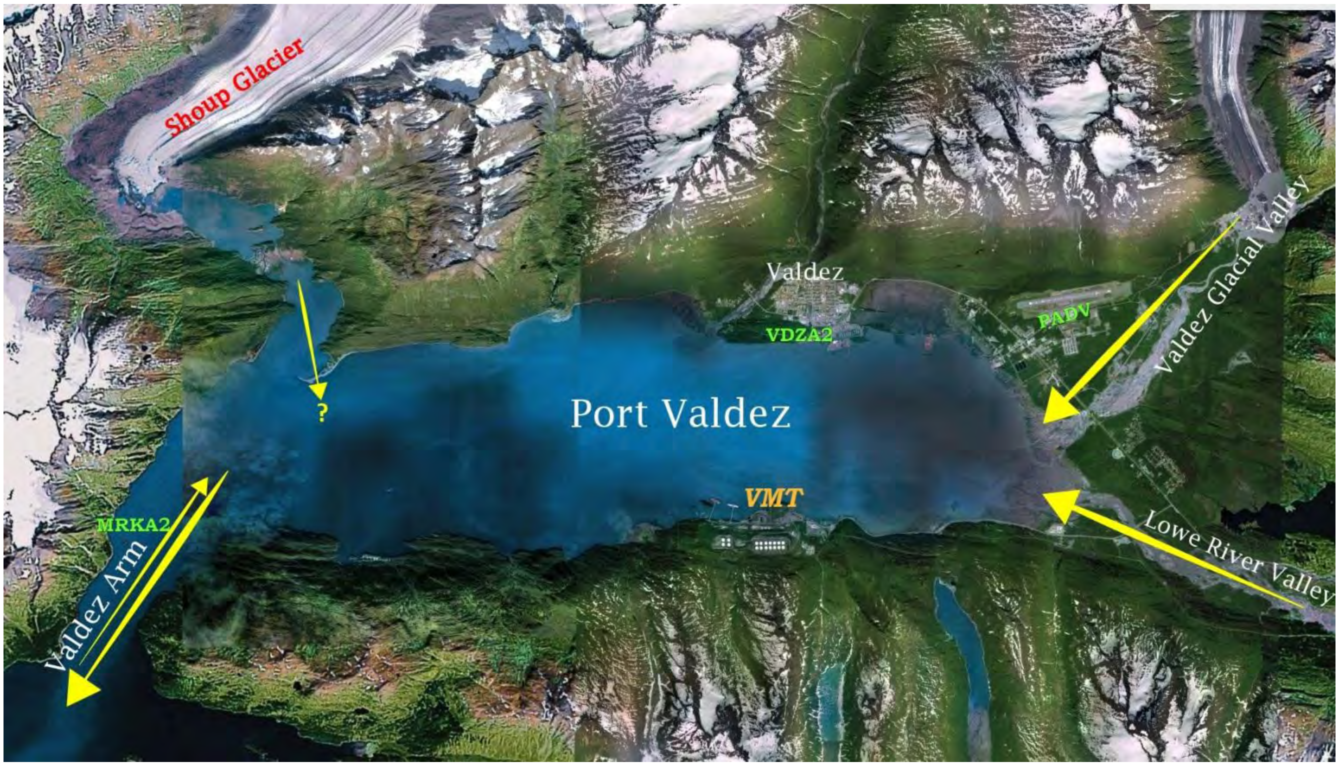

Figure 11. Terrain configuration of Port Valdez

The major drainage flows into Port Valdez are designated by the yellow arrows in Figure 11. The question mark with the arrow exiting Shoup Glacier Valley is meant to mark that this is probably a location for an occasional drainage flow, but since it is not instrumented, drainage flows here are conjecture. The most significant channeled flow regime associated with Port Valdez is the northerly ageostrophic down-gradient flow through the Valdez Arm. Channeled northerlies can present a significant navigational impediment to tankers and other vessels transiting these narrows. The impact of these wind conditions on Port Valdez is confined to the western third of and does not significantly affect cargo loading operations at VMT.

The east side of Port Valdez feels the effects of two drainage flow regimes, north-easterlies from Valdez Glacial Valley, likely induced by the same mesoscale pressure gradient configuration that produces the northerly flow in Valdez Narrows, and a southeasterly regime down the Lowe River Valley.

WIND MEASUREMENTS IN PORT VALDEZ

Surface winds in Valdez Arm are recorded by the National Data Buoy Center (NDBC), which maintains a Coastal-Marine Automated Network (C-MAN) station, MRKA2, at Middle Rock Light at the western margin of Port Valdez (Figure 11). MRKA2 probably does not feel the effects of Shoup Glacier Valley drainage flows. The only other publically archived wind recordings on Port Valdez are at two sites in the NE quadrant separated by only 6.4 km (4 miles) at the City of Valdez (Figure 12). These are the National Weather Service (NWS) site PAVD at the Valdez airport and the National Ocean Service site VDZA2 along the shoreline in the City of Valdez. Notably lacking are wind recordings in SE Port Valdez of winds as experienced at the VMT. The origins of easterly and southeasterly winds seen at the PAVD station are difficult to determine. Observed easterlies at VMT, that are currently attributed to Lowe River winds, may in fact be enhanced or in some cases even originated by flows from the Valdez Glacier Valley.

Figure 12. VDZA2 and PAVD weather stations location

HIGH WIND EVENTS AT PAVD

Given their close proximity and lack any significant intermediate terrain features , the wind climates of PAVD and VDZA2 are expected to be similar. However, Figure 13 — a three-year climatological summary of winds 15 knots or greater at PAVD and VDZA2 in wind-rose format— shows significant differences. VDZA2 presents an essentially bimodal distribution, with modes from the west (~270°) and NE (30° - 60°). Strong winds at VDZA2 (>30 knots) all had some easterly component (30°–120°). PAVD showed essentially *no* westerly mode of winds 15 knots or greater, with almost all winds from 60°–110°. While station wind direction results for both locations are broadly consistent with a general tendency for SE winds across PWS, the influence of E-W trending terrain enclosing Port Valdez is readily apparent.

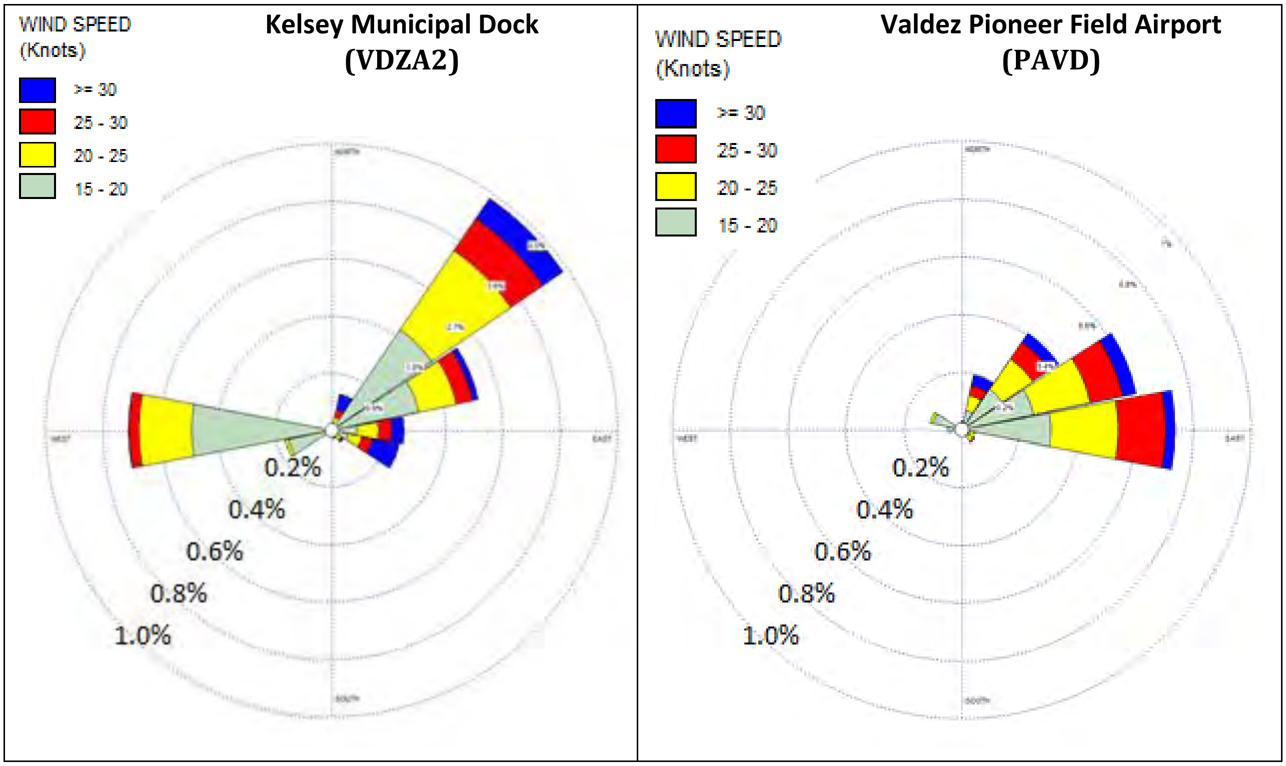

Figure 13. Wind roses for winds faster than 15 knots from 2009-2011 at two sites (VDZA2 and PAVD) in Valdez, Alaska.

High winds in Port Valdez are one of the biggest obstacles to cargo transfer at VMT. Evaluation of a time series of winds reveals that high winds usually occur in discrete wind events lasting for a few hours to, at most, a few days. An analysis was conducted of the frequency and strength of high-wind episodes for Port Valdez. Since the period of record (POR) for VDZA2 is only three years, the analysis was limited to evaluating the PAVD hourly time series for the available POR of 1975-mid 2012. An arbitrarily definition of a threshold wind speed of 30 knots (or greater) was chosen. The other criterion for an extreme wind episode, duration*,* was set to the minimum resolvable period of 1 hour, in order to capture the greatest possible number of events.

Table 1 shows that some 60 events can be identified during the 37-year PAVD POR. Note that this analysis approach may lead to a long-duration wind episode being multiply counted, as winds can briefly fall slightly below the threshold criterion only to increase again. 16 November 2011 is a good example of this. The majority of the high wind episodes occur during the cold season (November through March) in accordance with the prevalence of strong North Gulf of Alaska (NGOA) low pressure systems in this season. The episodes in Table 1 can be roughly categorized as two types: northerly events, with winds from 350°–20° and E (generally NE) events with a wider range of wind speeds, from 50°–100°. Northerly events, barely evident in the PAVD wind rose in Figure 13, probably result from strong mesoscale downslope winds that occur during extended cold periods in Interior Alaska when high pressure in the Interior and transient low pressure systems in the NGOA result in strong N-S pressure gradients and ageostrophic northerly surface drainage winds. While this is a common occurrence along the north flank of Prince William Sound, Port Valdez is often sheltered from the brunt of the flow by the high terrain to its north.

Table 1. Wind directions and speeds at PAVD from 1975-2012 with wind speeds equal to or greater than 30 knots and durations of at least 1 hour.

Date and Time (beginning)	*Direction (degrees)*	*Duration (hours)*	*Date and Time (beginning)*	*Direction (degrees)*	*Duration (hours)*
1975/10/30/_10:00	50	1	1983/10/03/_08:00	50	1
1975/10/30/_14:00	50	1	1983/10/03/_13:00	40	2
1976/02/08/_11:00	55	3	1989/01/20/_07:00	85	1
1977/04/26/_15:08	30	0.97	1989/01/29/_08:00	50	1
1977/04/27/_10:10	20	2	1989/01/29/_11:00	60	1
1979/02/06/_11:55	185	5.02	1994/01/06/_13:00	15	1
1979/02/14/_11:55	185	3	1994/11/29/_15:00	185	1
1979/12/12/_11:00	25	21	1995/12/02/_17:00	10	1
1979/12/12/_17:00	185	1	1995/12/04/_17:00	190	1
1980/01/01/_17:00	45	1	1996/12/21/_11:31	190	1
1980/01/02/_16:00	30	1	1997/03/12/_06:35	20	3.15
1980/01/10/_10:00	40	4	1999/01/04/_10:51	80	1
1980/01/29/_13:00	185	1	2003/03/12/_18:00	95	1.33
1980/12/07/_11:00	15	1	2005/01/16/_21:16	85	1.4
1980/12/25/_17:00	185	3	2005/01/17/_14:36	85	1
1982/01/05/_15:00	185	7	2005/11/05/_04:36	85	1
1982/01/06/_11:00	50	2	2005/11/05/_11:36	75	1.73
1982/02/09/_14:00	60	1.58	2005/11/05/_13:16	85	1.33
1982/02/22/_10:25	30	1	2006/03/10/_12:36	75	1
1982/02/22/_14:00	40	48	2010/11/16/_17:56	80	1
1982/02/22/_17:00	50	1	2010/11/29/_18:16	15	1
1982/02/25/_11:00	50	2	2010/11/30/_06:16	65	2
1982/02/25/_16:00	40	1	2010/12/18/_23:36	90	1
1982/02/26/_12:00	355	3	2011/02/14/_05:36	75	1.33
1982/02/26/_15:00	30	3	2011/11/16/_01:56	75	1.33
1982/04/02/_13:00	40	1.17	2011/11/16/_12:36	35	1.67
1982/10/20/_11:50	185	4	2011/11/16/_15:36	30	1
1982/10/26/_14:00	15	7	2011/11/16/_18:36	25	2
1983/01/11/_10:00	30	1	2011/11/16/_21:16	45	1
1983/09/24/_09:00	50	2	2012/01/14/_03:16	90	2

By contrast, the easterly events are often a much smaller-scale response to more localized pressure gradients. It is significant that most of these episodes are northeasterly, as would be expected from a local drainage flow out of the Valdez Glacier Valley (Figure 11). Also apparent in Figure 11 is the proximity of VMT to the likely path of outflow from the Valdez Glacier Valley. Since, there are no robust records of weather-related closures at VMT, the closure periods cannot be correlated with PAVD wind episodes.

There are three known separate occasions– 30 December, 2008, 5 January, 2009, and 21 January 2012– when cargo-transfer delays occurred due to weather conditions at VMT Berth 4, yet none of the wind episodes at PAVD identified in Table 1 were coincident with these dates. This suggests that PAVD high-wind episodes are not reliable indicators of adverse weather conditions at VMT.

The wind conditions during the 21 January 2012 VMT closure were investigated with the use of a high-resolution (3km-grid) mesoscale atmospheric forecast model, PWS-WRF, which is run routinely twice-daily at UAA's Alaska Experimental Forecast Facility (AEFF). Figure 14-A shows surface wind speed (shaded) and wind direction (vector arrows) at 13:00 AKST on 21 July 2012 for the NGOA and associated coastal regions, notably PWS and Cook Inlet. Port Valdez, the area of interest, is marked by the magenta dot and oval. The surface wind conditions depicted here are rather quiescent for this region during the cold season. The higher winds (yellow , ~40 knots) in general correspond to higher elevations. The significant sea-level exception to this is the NW jet exiting lower Cook Inlet through Kennedy entrance. Surface winds in the PWS region in general are multidirectional, showing considerable local variability and indicating the lack of strong synoptic-scale pressure gradients.

Figure 14-B shows a closer view at north PWS. The wind barb (yellow) shows the 13:00 observation of wind speed (13.9 knots) and wind direction (120°) at PAVD. The wind speed is slightly over-predicted by the model at 16.3 knots (a known bias). The model wind direction of 36° is almost 90° out of phase with that observed. Given the spatial resolution of the model (4·Δx, in this case 12 km) and the scale length of topographic variation (~1 km), this is not a surprising outcome.

The model wind direction is also in good agreement with climatology (both Figure 13 and Table 1), if not at this particular time in the observations.

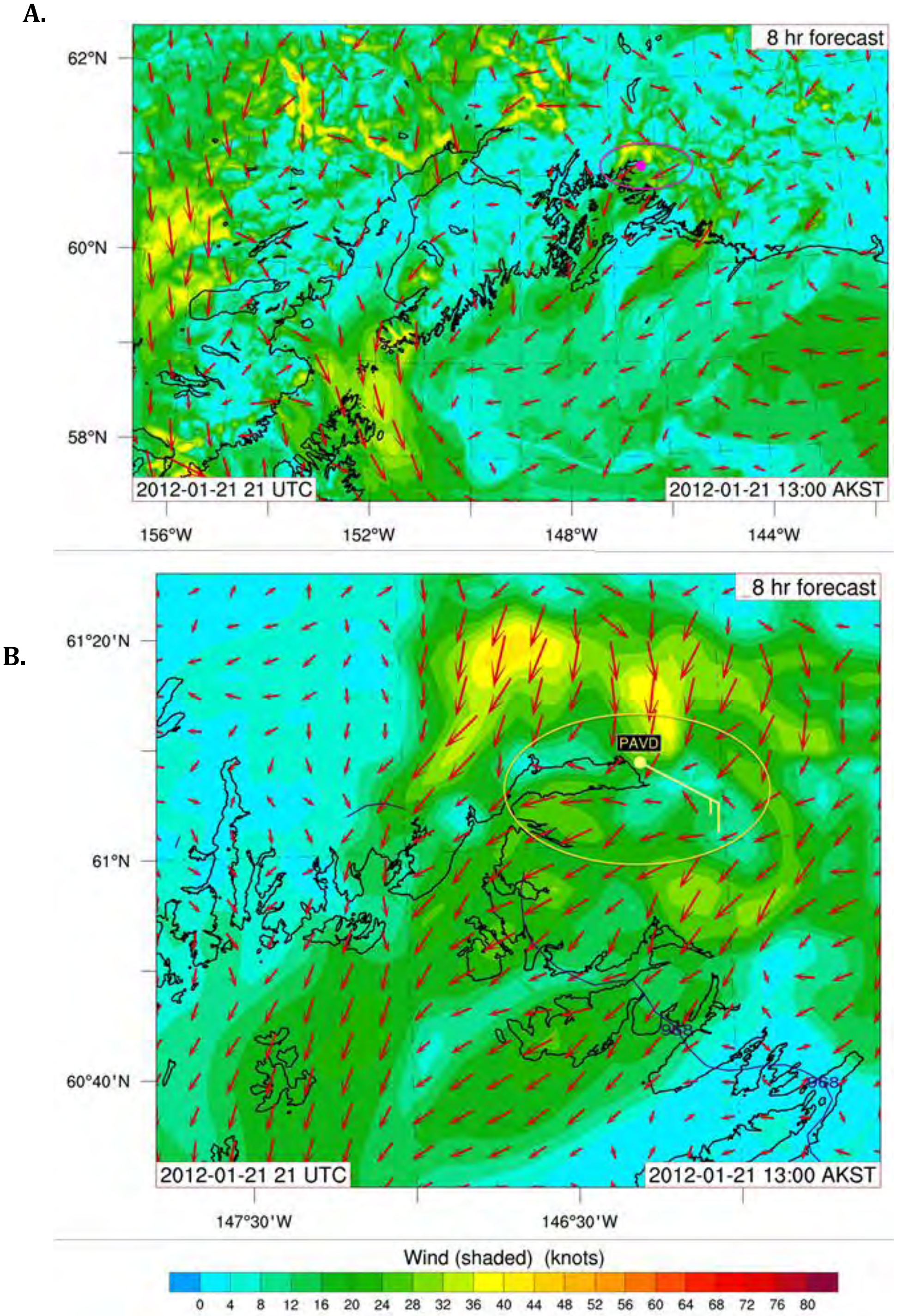

Figure 14. PWS-WRF wind speed and direction outputs for the NGOA and associated coastal regions (13:00 AKST on 21 January 2012)

The model winds show a strong cyclonic veering from northerly in eastern Port Valdez to easterly by mid Port Valdez. The wind vector in mid Port Valdez aligns quite well with PAVD observation. A strong N-S gradient exists across Port Valdez. At its E-W midpoint, the wind varies from 12 knots (N) to 25 knots (S), more than a doubling of wind speed. Anecdotal evidence (*e.g.,* during the October 2012 site visit) suggests that this tight N-S isotach gradient exists with other overlying atmospheric conditions as well.

WIND GENERATED WAVES

The average water depth in Port Valdez is 1600 feet (490 m), with an average water depth in the east part of the bay of 1000 feet (300 meters). As it was mentioned earlier, Port Valdez is about 6 km wide and 22 km long. In these conditions, waves generated by winds are fetch-limited. Based on the distribution of winds from PAVD (1975-mid 2012), station elevation (36 meters), and fetch measurements (Figure 15), wave height and period are estimated using U.S. Army Corps of Engineers Coastal Engineering Manual, chapter II-2 (Table 2). As it can be seen from Table 2, waves generated by strong winds (30 knots or higher) are at least 0.75 meter (2.5 ft) significant wave height with period of 2.5 to 3 seconds.

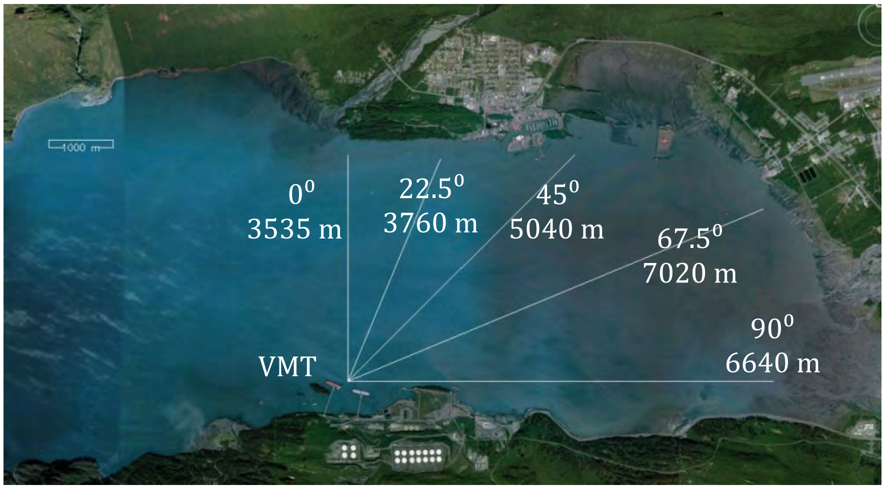

Figure 15. Fetches of onshore wind speed classes (direction and length)

Table 2. Wave height and period for prevailing onshore wind speed classes

Wind Speed			**Onshore Wind Speed Classes**				
knots	**m/s**		**348.75^{0} - 11.25^{0}**	**11.25^{0} - 33.75^{0}**	**33.75^{0} - 56.25^{0}**	**56.25^{0} - 78.75^{0}**	**78.75^{0} - 101.25^{0}**
0-5	1.3	**%**	0.48%	0.57%	0.95%	1.92%	4.66%
		H	0.03	0.03	0.04	0.05	0.04
		T	0.86	0.88	0.97	1.08	1.06
5-10	3.9	**%**	0.38%	0.45%	0.66%	1.19%	1.97%
		H	0.12	0.12	0.14	0.17	0.16
		T	1.33	1.36	1.50	1.67	1.64
10-15	6.4	**%**	0.08%	0.13%	0.23%	0.23%	0.36%
		H	0.23	0.24	0.27	0.32	0.31
		T	1.66	1.69	1.87	2.08	2.05
15-20	9	**%**	0.06%	0.10%	0.15%	0.18%	0.20%
		H	0.36	0.37	0.43	0.51	0.49
		T	1.92	1.96	2.17	2.42	2.38
20-25	11.6	**%**	0.02%	0.04%	0.05%	0.08%	0.11%
		H	0.51	0.52	0.60	0.71	0.69
		T	2.16	2.20	2.43	2.71	2.66
25-30	14.1	**%**	0.04%	0.08%	0.06%	0.07%	0.08%
		H	0.67	0.69	0.80	0.94	0.92
		T	2.37	2.42	2.66	2.98	2.92
>30	15.4	**%**	0.02%	0.02%	0.03%	0.02%	0.02%
		H	0.75	0.78	0.90	1.06	1.03
		T	2.47	2.52	2.78	3.10	3.04
%-percent occurrences of winds				H-wave height (m)		T-wave period (s)	

PRELIMINARY CRITERIA FOR MITIGATION MEASURES

Three practical objectives are defined for the purpose of formulating mitigation measures, defined in terms of a risk reduction objective and as an associated operational improvement:

1. Reduce risk of an oil spill escaping containment at VMT Berth 4.

    a. Formulate measures that improve boom effectiveness during extreme winds.

2. Reduce risk of TAPS shut-down due to halted product transfer at VMT Berth 4.
    a. Formulate means by which product transfer can continue during extreme winds.
3. Reduce risk of injury to crews and damage to vessels and equipment during boom deployment in extreme winds.
    a. Formulate means by which oil boom can be more safely deployed and maintained during extreme winds.

CRITERIA BY WHICH TO JUDGE ALTERNATIVE MITIGATION PROPOSALS

East to northeast winds higher or equal to 30 knots sustained at least for 1 hour, during which:

- Boom is safely deployable, and
- Deployed boom continues to provide effective oil spill containment.

MITIGATION ALTERNATIVES

MOORING A TUG UPWIND AT BERTH 3

Figures 3 illustrate the position of Berth 3 due east of Berth 4. An escort tug (Figure 16) or other large vessel positioned there would improve to some degree the shelter provided by Berth 3 and the shoreline from which it extends. This measure has been tried, according to knowledgeable PWSRCAC and SERVS officials, but apparently did not succeed in substantial mitigation of concerns for either boom effectiveness or safety of crews, vessels, and equipment. Figure 3 shows that even another supertanker at Berth 3 will provide only limited shelter from northeast winds and waves.

Figure 16. SERVS escort tug (PWSRCAC photo)

POSITIONING A TUG UPWIND AT BERTH 3 DIRECTING ITS WHEEL WASH NORTHWARD

This measure has also been tried and apparently marginally improved the wave shelter provided in two ways. First, the length of the tug's hull across the wind increased the shadow zone and shelter from winds and waves. Second, the wheel wash from the tug's propellers, also directed across the wind, disrupted water particle motion that accompanies sea waves, providing a calming effect. According to SERVS personnel on scene, this effort still did not significantly mitigate concerns for either boom effectiveness or safety of crews, vessels, and equipment.

TUG AND BARGE DYNAMICALLY POSITIONED DIRECTLY UPWIND OF BERTH 4

This alternatives, suggested by Mark Swanson (Executive Director of PWSRCAC), involves positioning a tug and oil spill response barge (Figure 17) with their hulls aligned across the wind before the primary boom at Berth 4 to provide wind and wave shelter. Dynamic Positioning (DP) equipment and procedures, as applied in the offshore industry, could keep the tug and barge aligned upwind at an orientation and distance to provide optimum wave shelter. Offshore drilling vessels use computer-controlled DP systems with multiple azimuth drives (directed propellers) to automatically maintain a precise position.

The capabilities of the tugs now available to SERVS on site would have to be evaluated with a view toward keeping the tug and a barge on station across the wind in the extreme conditions defined above (30-knot winds and 2.5-ft waves) with either manual or automated control. Automated DP systems might require expensive modifications or charter of a tug with these capabilities. A propulsion failure of a tug with a single drive system might result in the tug and barge drifting downwind onto the boom, tanker, and terminal. A tug with multiple azimuth drives could move the barge away with a single drive, if needed.

Figure 17. Oil spill response barge on station at Valdez (PWSRCAC photo)

HARBOR-TYPE FLOATING BREAKWATER DEPLOYED UPWIND

Harbors and other coastal facilities are protected in many instances by floating breakwaters composed of linearly connected masses, such as concrete-covered foam, steel pipes, log rafts, rafts of automobile tires, and other materials, anchored across exposure to damaging waves. Depending on the specific configuration, floating breakwaters reduced wave energy in their lee by a combination of wave reflection and attenuation of wave energy to move the floating mass against its anchors (Morey, 1998). In comparison to a permanently fixed rock breakwater, floating breakwaters possess a number of advantages including lower capital cost, mobility, suitability for deep water sites, and accommodation for a variety of bottom conditions. They also have the disadvantage of limited effectiveness, particularly in long-period waves, like ocean swell.

A floating breakwater could be deployed offshore of Berth 3 to reduce wave heights at Berth 4, as illustrated in Figure 18. Floating breakwater can be anchored in the position permanently or temporarily only during adverse weather events. Permanent anchoring might create a maneuvering hazard for tankers, tugs, and other vessels in Port Valdez. Temporary anchoring would still require permanently positioned anchors with lines retrievable in extreme conditions. An area to moor the floating breakwater in calm weather would have to be provided. While swell is unlikely to be encountered in Port Valdez, the worst conditions may render a floating breakwater only partially effective as a wave barrier, based on experience with floating breakwaters at Whittier on western Prince William Sound and other Alaskan fjord sites.

Figure 18. Possible floating breakwater location (dashed line)

Reflective breakwaters utilize large vertical or inclined surface to reflect incoming wave energy back out to sea. Efficiency is most sensitive to the depth of the reflecting surface and the overall structure stability provided by a stiff mooring system (Morey, 1998).

Transformation breakwaters convert incident wave energy through induced motion response into secondary wave trains of various heights and periods. Attenuation is influenced mostly by mass, periods of motion, and structure width to wave length (Hales, 1981). A typical design is the Alaskan “ladder” (Figure 19), a double pontoon system constructed from polystyrene foam blocks covered with concrete. The two large pontoons are held in position using a series of braces to provide additional stiffness and flotation.

Figure 19. Alaskan floating breakwater design at Bar Point Harbor in Ketchikan, Alaska (photos by Lt. Jon-Paul Navarro, Arctic Engineer, 2010)

Alaskan "ladder" breakwater can be designed to provide adequate response to waves at VMT terminal. However, an adequate anchoring system is critical for these structures to be effective and to keep them from breaking free and drifting downwind onto the boom, tanker, and terminal. If they were to break away from their mooring chains, they can cause a severe damage. Also, they require regular inspections of connection components affected by salt water and general ware on moving parts.

Dissipative breakwaters convert wave energy into turbulence or friction by breaking waves on sloping surfaces or against structural members. This floating breakwater design has been used extensively in attenuating wind generated chop (Morey, 1998). A good example of dissipative breakwater is the interwoven tires system, such as Goodyear and Wave-maze designs, constructed from used automobile and truck tires (Figure 20).

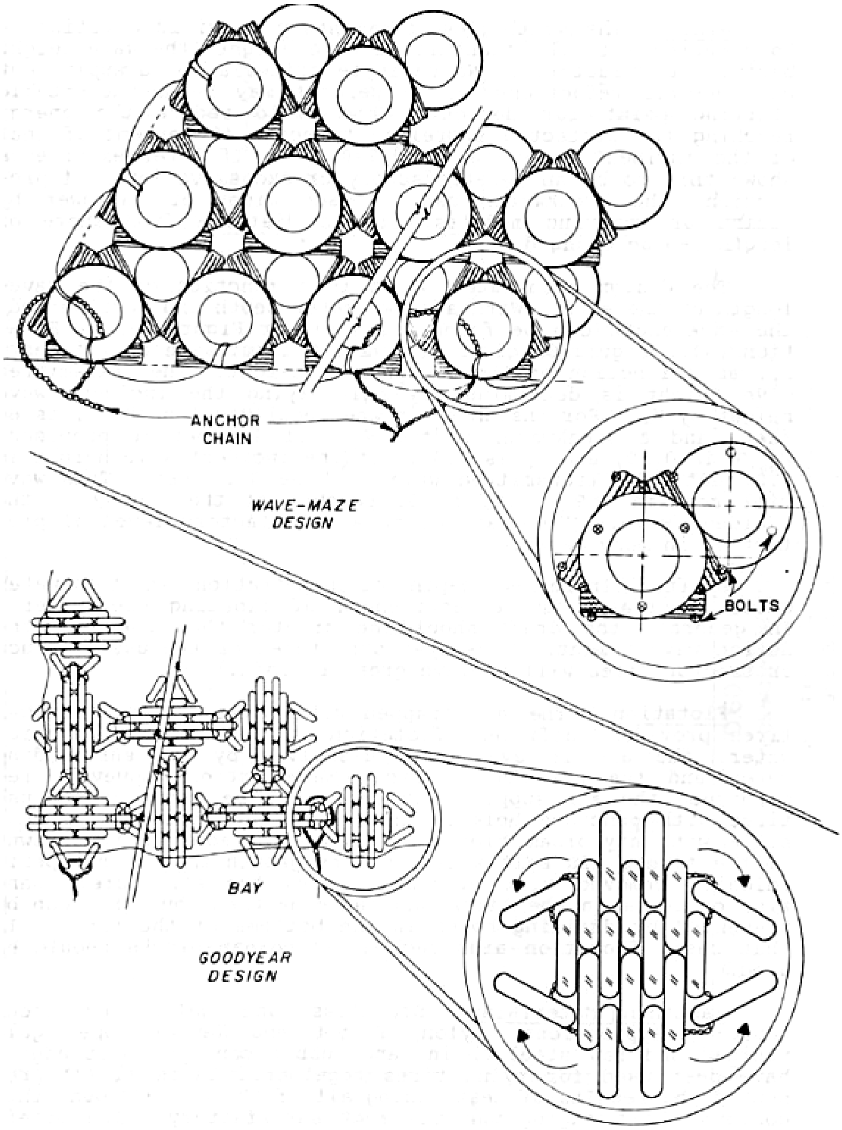

Figure 20. Floating tire breakwater modulus (Hales, 1981)

An interwoven tires system is more affordable than a concrete floating breakwater and with their lesser mass and rubber exterior, are less destructive, if the system were to break free. Floating tire breakwaters need to be 1-5 times as wide as the design wave length and consequently utilize considerable area. Other disadvantages include their large number of connections in constant motion and their propensity to accumulate spray ice in cold weather. Floating tire breakwaters are not as effective as concrete breakwaters in high waves.

Hybrid floating breakwaters typically utilize a combination of reflection and transformation mechanisms. They have various cross section designs (Figure 21) constructed from reinforced concrete. These systems can be designed to provide a relatively high level of performance in high waves, compared to other floating breakwater designs. However, main disadvantages are similar to Alaskan “ladder” design, those are ware out of connections between modules and high hazard if break lose.

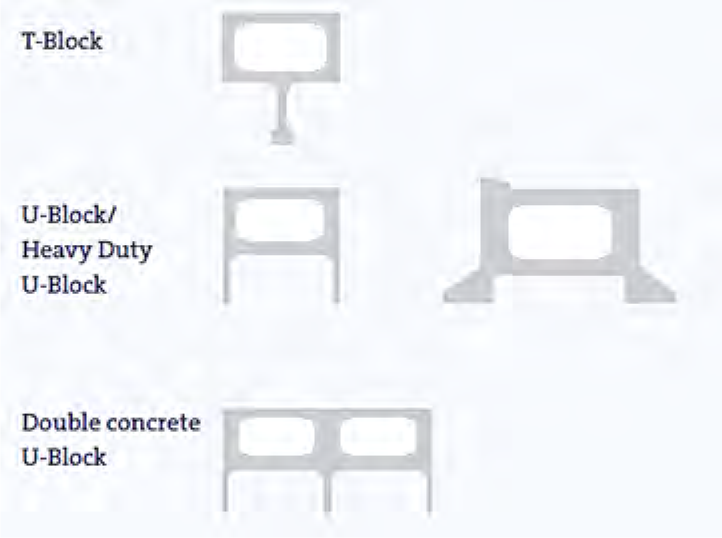

Figure 21. Typical cross-sections of hybrid floating breakwater (FDN Engineering, 2010)

In summary, floating breakwaters of these types sometimes used to protect harbors have limited capabilities as wave barriers, but would be effective to some degree in Port Valdez conditions. They typically require complex anchoring systems, are prone to deterioration at connections between modules, and accumulate spray ice. While a free-floating raft of tires would be less harmful than concrete modules to a tanker and VMT terminal facilities, it would certainly disrupt the primary oil boom surrounding the tanker, if broken free in extreme winds. All types of floating breakwaters would constitute a hazard to navigation while deployed across Port Valdez opposite VMT Berth 4.

EXTRA BOOM, AS A FLOATING BREAKWATER

This measure was attempted in the 1990's with marginal effectiveness that depended on the particular configuration (personal communication, John Kotula, Alaska Department of Environmental Conservation). Oil booms have a limited capacity to provide shelter acting as a floating breakwater, but they do reflect and attenuate some wave energy. A length of boom anchored or held in place by vessels fully across the wind before the primary boom would calm the water to some degree, perhaps enough to maintain effectiveness of the leeward primary boom.

Literature on effectiveness of oil booms as floating breakwaters is sparse. Alaska Clean Seas, an organization whose mission is similar to SERVS, has deployed an oil boom as a floating breakwater to protect oil spill response vessels and facilities at West Dock in Prudhoe Bay (Figure 22). Lee and Kang (1997) considered deployment of an oil boom as a breakwater to protect a leeward boom and concluded that, to provide adequate performance, the distance between deployed booms should be at least 8 times the draft of the boom. The depth of the skirt, rigidity of the tension member at the bottom of the skirt, and freeboard (*i.e.,* diameter of the flotation tubes) probably improve effectiveness as a wave barrier. The NOFI 800S boom, of the two models available at VMT, would probably be the most effective wave barrier by these measures. An additional length of boom anchored or held by vessels windward of the VMT Berth 4 is conceptually illustrated in Figure 23. The windward breakwater boom would have to be about 700 meters (2,300 ft) in length to shelter the primary boom surrounding the tanker.

Figure 22. Oil boom deployed by Alaska Clean Seas as a harbor breakwater at Prudhoe Bay (photo by Orson Smith 2006)

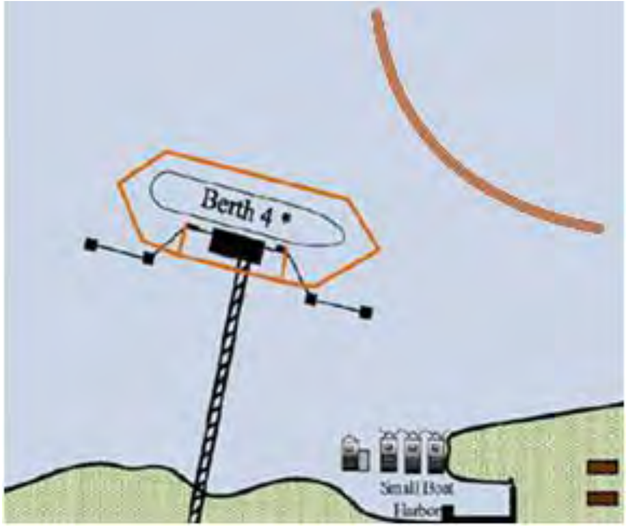

Figure 23. Extra boom location northeast of VMT Berth 4

RE-ARRANGEMENT OF EXISTING BOOM ANCHORING SYSTEM

Booms are known to be sensitive to a current angle of approach and they are very likely to fail if deployed at a 90°angle, disregarding the speed of the current. Due to the anchoring configuration, there is a small section of the boom that is deployed almost perpendicular to northwest direction (in red, Figure 24). Re-arrangement of an anchoring system might improve performance of the boom. Anchoring the boom at a small angle to the direction of oncoming waves might prevent overtopping (Figure 24). Additional boom would be required to accomplish this.

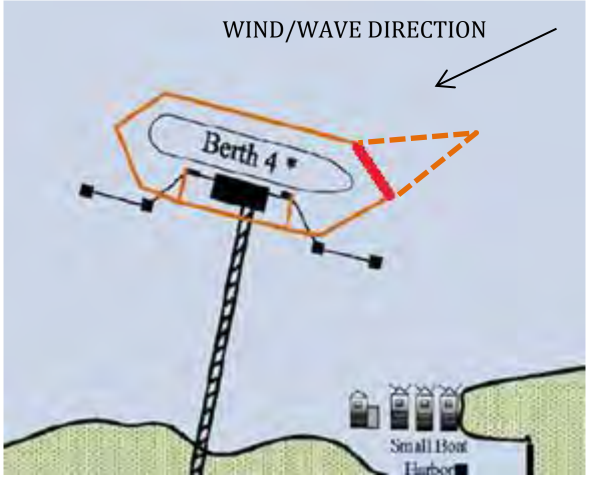

Figure 24. Re-arrangement of boom anchoring (proposed changes shown by a dash line)

BUBBLE CURTAIN

A perforated hose or pipe of compressed air can create a curtain of bubbles along its length that disrupt wave-induced water particle motion This disruption results in a breakwater effect, reducing wave energy on the leeward side of the curtain. This concept has also be considered as a means to contain an oil spill (Figure 25, MCA 2009) by virtue of the divergent upwelling current created at the surface by the rising bubbles. The more air the compressor can force out of the hoses, the greater resistance to waves and currents. However, to double the effect of the bubble curtain on the current, the air flow rate must be increased by a factor of eight, so the limitation of bubble barriers lies in the compressor power available (Benjaminsen, 2009). Anyone who has experienced extreme winter winds and waves in an Alaskan fjord will intuitively conclude that this mechanism would be completely overwhelmed by natural wave turbulence and is impractical as a mitigation measure at the VMT.

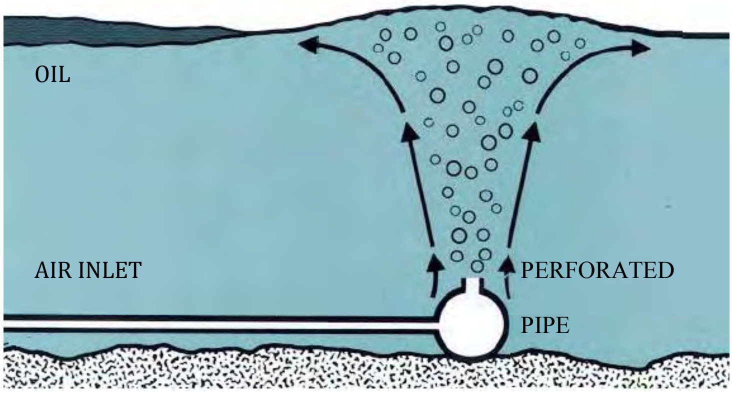

Figure 25. Schematic of bubble barrier (MCA, 2009)

CONCLUSION AND RECOMMENDATIONS

Findings summarized above lead to the following conclusions and recommendations regarding mitigation concepts are intended in severe easterly winds to allow oil boom to be more safely deployed around ships at VMT Berth 4 or maintain the containment effectiveness of a boom already deployed there.

1. Deployment of a harbor-type floating breakwater, including concrete, floating tire, or similar systems, is <u>not recommended</u> due to:
    a. the risk of severe damage to the oil boom, tanker, and terminal structure, if heavy, rigid concrete units accidentally break free and drift downwind, and
    b. the navigational hazard created by positioning the system upwind of Berth 4 near enough to be effective as a wave barrier.
2. A bubble-curtain system is <u>not recommended</u> as impractical to deploy and as ineffective in extreme conditions of Port Valdez.
3. Operational experiments are <u>recommended</u> for the following measures, which hold promise for improving the safety of primary boom deployment and its effectiveness in extreme wind conditions:
    a. deployment of another length of oil boom upwind of the primary boom location, either anchored or held in place by tugs,
    b. deployment of a tug and an oil spill recovery barge upwind in a dynamic positioning mode.

Wind extremes on the south side of Port Valdez at the VMT are not well represented by wind speed and direction measured on the north side at either PAVD or VDZA2. Evidence of models and preliminary analysis of orographic influences and regional meteorological patterns indicates conditions on the south side of Port Valdez are often substantially different from those on the north side, particularly with easterly winds. Installation of a recording anemometer station, with other standard meteorological sensors and perhaps a web camera, is recommended on the shore or on a buoy in the vicinity of the VMT. Future incidents of extreme conditions need to be better documented, including records of rise to a critical threshold, duration above that threshold, and subsequent fall of wind speed. This information can supplement the expert judgment of SERVS, State of Alaska, federal officials with regard to halting transfer of oil to tankers or sending crews out in hazardous conditions to maintain or deploy boom around a tanker at berth. The conditions prevailing during an accident will be much better documented with continuously recorded winds on site and this information will improve the situation awareness of responders.

The worst-case scenario of a Trans-Alaska Pipeline shut-down can be avoided by assuring that sufficient storage capacity remains in service at VMT, such that cessation of oil transfer to tankers in severe weather can be occasionally accommodated. The measures recommended above will also serve in the undesirable event that a spill accidentally occurs at the berth and severe weather arises when containment depends on the effectiveness of the boom surrounding the tanker and berth.

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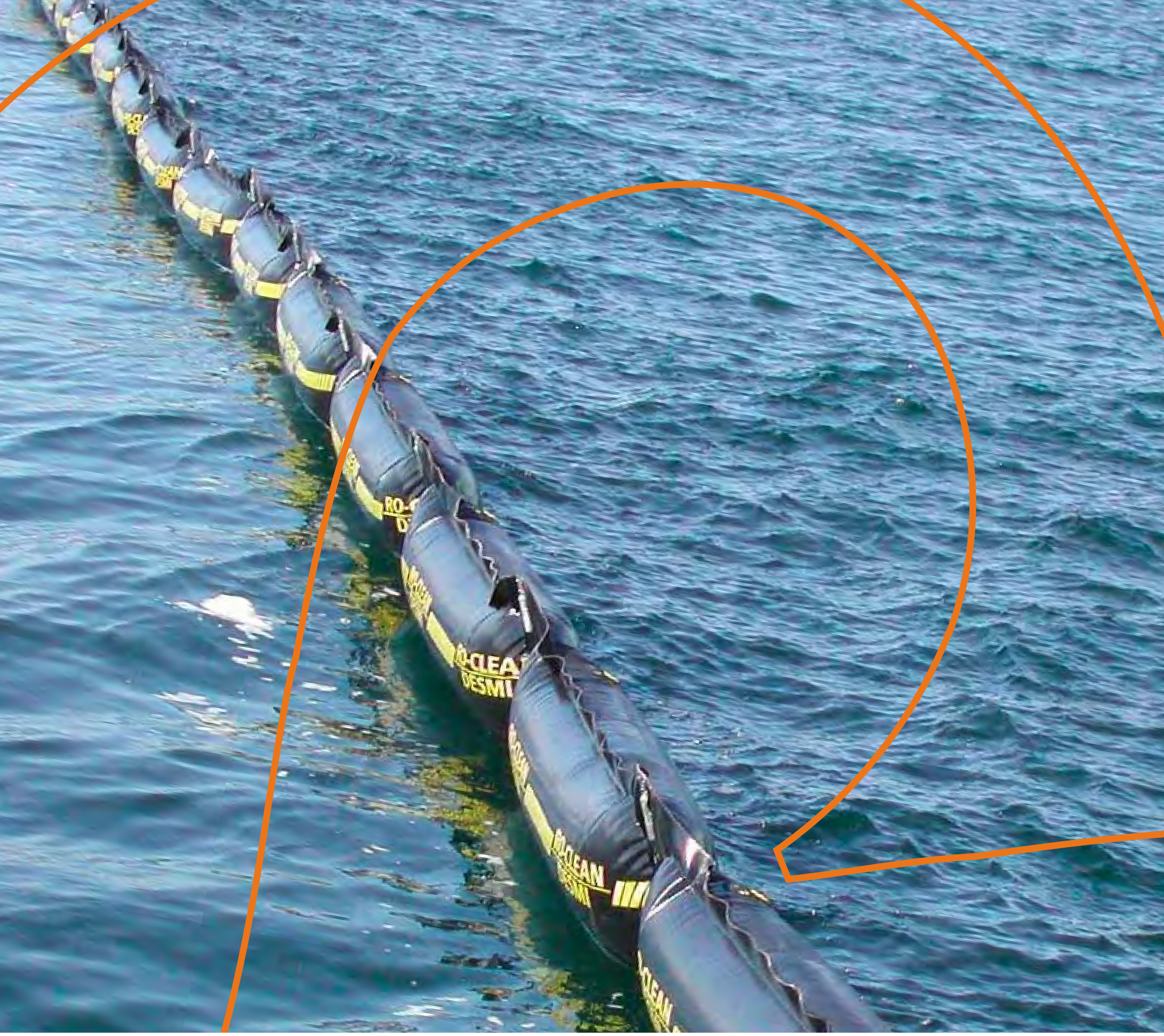
APPENDIX A

Ro-Boom 1500 and NOFI 800S boom brochures



RO-BOOM 1500 - Heavy-duty oil containment boom

PROVEN OIL SPILL TECHNOLOGY

PROVEN TECHNOLOGY

DESMI

RO-BOOM 1500 - Heavy-duty oil containment boom

RO-BOOM 1500 is the most popular model of RO-BOOM ever produced by DESMI Ro-Clean. It is stored in large quantities in many response centres around the world, and has been deployed very successfully in many spills.

The RO-BOOM 1500 heavy-duty containment boom comes as standard with ASTM or hinge connectors and 4.5 metre air chambers.

RO-BOOM 1500 is made from synthetic, oil and weather resistant Neoprene rubber and Hypalon. RO-BOOM 1500 will withstand the effects of sun, sea and oils, which destroy many plastic booms. Attachments, such as eyelets and brackets are made from stainless steel, AISI 316.

The boom has moulded, inflatable chambers - the total freeboard is approximately 0.50 m, and the overall height of the boom in inflated condition is approx. 1.20 m. The individual buoyancy chambers have separate air valves, which mean that in the unlikely case of puncture only one chamber will lose air, and not impair the integrity of the boom.

The smooth surface of the deflated boom makes cleaning easier - several types of oil do not stick to the boom at all.

Advantages of RO-BOOM:

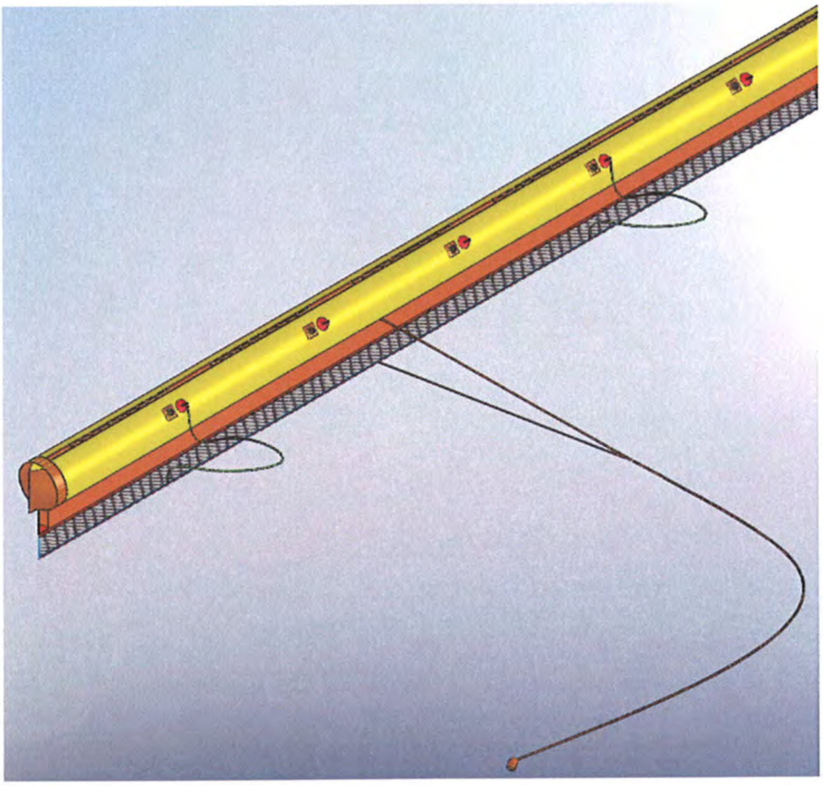
- A durable boom resistant to abrasion, oils and sunlight
- Individual air chambers for reliability and security
- Lies flat when deflated for easy storage and cleaning
- Stainless steel and hot galvanized components
- High visibility stripe
- Reels, containers and bags available
- Our most popular model
- Proven performance
- Rapid deployment
- Third layer of fabric at the chain attachment area for added strength

TECHNICAL DATA

RO-BOOM 1500 oil containment boom is manufactured from heavy-duty Neoprene rubber with a Hypalon external skin. This unique one-piece moulded composite construction has complete cross vulcanisation of rubber and reinforcing fabrics. The construction is seamless, it has high abrasion resistance, peel resistance and tensile strength. RO-BOOM lies completely flat when deflated allowing for easy cleaning and storage. The individual air chambers provide high integrity. RO-BOOM is fitted with stainless steel fittings and a hot galvanized ballast/tension chain. Internal fibreglass rods secured with stainless steel brackets. These rods ensure optimum skirt profile under tow. ASTM quick connectors or stainless steel hinge connectors are fitted as standard.

Width (Deflated):	1.50 m / 59 in
Standard section lengths:	50, 100, 200 m / 164, 328, 656 ft
Freeboard:	0.50 m / 20 in
Operational depth of skirt:	0.70 m / 28 in
Operational weight (inclusive of chain):	12 kg/m / 8.0 lbs/ft
Buoyancy chamber length:	4.5 m / 177 in
Section connector:	ASTM
Section connector:	ASTM or Stainless steel hinge or pin
Tensile strength of boom wall:	315 N/mm / 1,795 lbs/in
Breaking load of chain:	200 kN
Operational temperature range:	-20°C to +70°C
Stored temperature range:	-40°C to +70°C

NOFI
TROMSØ



Document Name

NOFI 800S VMT

USERS MANUAL

NOFI Document no. / *Dokument nr.:*

L176 - M - 650

A	**02.03.09**	**Customer**			
Revision *Revisjon*	Date (d,m,y) *Dato (d,m,å)*	Issued for *Utgitt for*	By *Av*	Checked *Sjekket*	Approved *Godkjent*

TABLE OF CONTENTS:

GENERAL

This manual describes the use of the **NOFI 800S VMT.**

The NOFI 800 VMTS is specially designed for permanent anchoring at the Valdez Marine Terminal during winter season. The VMT boom is made of the first grade materials to get the best properties with regards to oil and winter exposure.

Cleaning

All fabrics are vulnerable to damage when dragged over sharp edges, rough concrete and asphalt etc. Such surfaces and sharp edges must be covered with tarpaulin or similar. After use in oil the equipment should be cleaned as soon as possible, see Cleaning Procedure: **F000-N-680**

Storage

During outdoor storage, the equipment must be covered with a tarpaulin to avoid damage from sunlight. If stored in a closed container etc. proper ventilation should be provided to prevent growth of micro-organisms.

SAFETY: Any boom handling and especially high speed operations involve heavy forces and impose a safety risk. In order to avoid personnel injuries, sound seamanship should be practised in all operations. Local safety regulations and practice must be followed.

SAFETY: In order to avoid injuries to personnel, when using a Back-Pack fan make sure that the hose is secured or held tightly during all operations.

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Spare parts

Spare parts are packed in watertight PVC bag, for details see Data sheet **L176-F-510** and Drawing **L176-A-102.**

No.	**Description**
1	Polyester reinforced PVC fabric 1100 g/m² Orange, TYPE 68715
2	Polyester reinforced PVC fabric 1040 g/m² Orange, TYPE 4500
3	PU/PVC fabric 1400 g/m² Yellow, TYPE 4502
4	Plastic coated rope 8 mm with connection hooks
5	Glue
6	Plastic strips
7	Strongback ropes
8	Tie Off Point
9	Monsun XII valve
10	Monsun Tools
11	Sikaflex
12	Nylon line
13	Watertight bag

SYSTEM DESCRIPTION

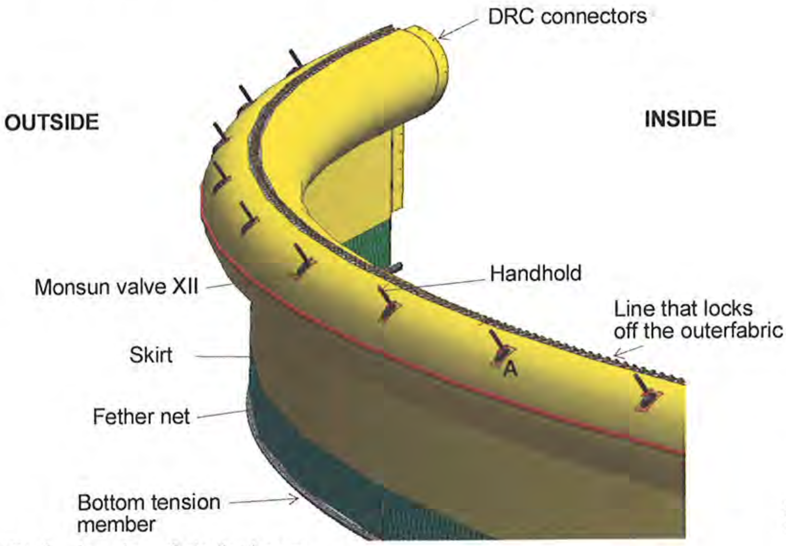

Fig.1: Iso view of similar boom

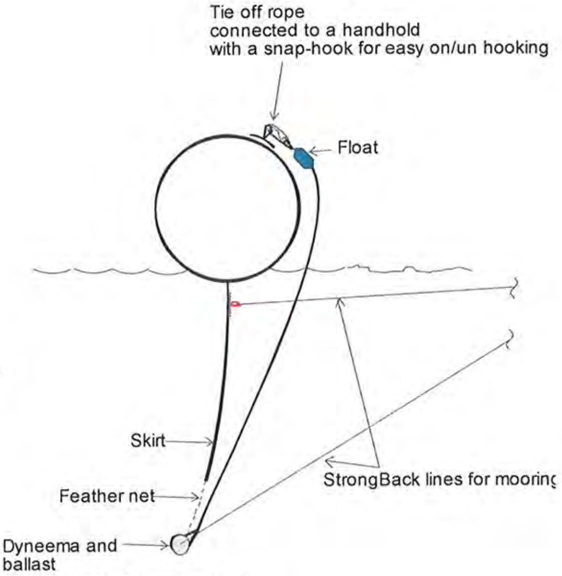

Fig 2: Cross-section

Outer fabric

The outer fabric is folded over the air chambers and connected on top by plastic eyelets and cleats locked by a plastic covered rope, which may be disconnected during cleaning if the system is heavily contaminated.

Air Chambers

The NOFI 800S VMT has 12 off individual air chambers, 3m long. The air chambers has eyelets on top. These eyelets comes thru female eyelts on the outer fabric and are locked of with a coated rope that runs thru the eyelet holes. The air chambers are filled with a backpack fan or similar thru a Monsun XII valve on each individual air chamber.

Monsun Valve and Valve positions

When the boom comes out of the reel the valves are in open position. Before inflation of chambers make sure that the MONSUN valves on the air chambers are closed. valve are closed by pushing the valve plate down and turn to left. To set the valve in open position you press down and turn right.

Hand holds

By each valve there is a Handhold. It is intended for positioning work boat during air filling. It is not meant for tying off boats or other vessels.

Strongbacks

There is two anchor points, Strongbacks, on each 40m section. They are situated between 2nd and 3rd air chamber from each end of the section. The Strongbacks consist of a mooring bridle with connects to the boom on two points. One point on the bottom tension member and one on the skirt, see figure 2.

Tie off Points

To be used for tying off Workboat while you work with the boom. On each 40m section there is 4 tie off points. The tie off point is a line that is connected to the bottom tension member and connected to a Handhold by a Snaphook for easy release. The line is 8m long HOLD and makes it possible to reach several valves by one line.

CONNECTORS

Since two types of boom will be used in during operations at VMT there is a need for conneting the two different booms together. The NOFI 800S VMT boom is delivered with two different connectors the Back Fence Connector (BFC) and the Tow end Connector (TEC).

BACK FENCE CONNECTOR

For details see **L176-A-104**

TOW END CONNECTOR

For details see **L176-A-102**

DEPLOYMENT

Communication

Establish communication between:

1. Responsible person for operation.
2. Person in charge aboard towing vessel.
3. Boom Reel operator

Inflation

Inflation is normally done by a backpack type fan. Electric and hydraulic fans may also be used.
The air chamber is pressurised to maximum level, approximately 100 mbar.

The Monsun XII valves have an open and a closed position. When the valve seat (plate) is pressed down and turned to the right the valve is locked in open position (as is done during retrieval). When turning to the left the valve is closed. It is still possible to perform inflation with the valve in closed position, since the air pressure presses down the spring activated valve seat, thus letting air in.

NOTE: In order to attain sufficient pressure in the air chambers, inflation must be performed with the valve plate in **closed** position. Let the fan run at full speed until the inflation hose nozzle has been pulled out of the valve. The spring-activated valve closes automatically and no air pressure is lost during opening and closing of the valves.

When the towline is pulled out, the boom will appear and you can start the inflation immediately. When starting inflation, make sure that both deck hands performing the inflation fully understand that each air-valve will be found in open position. This means that before inserting the air-hose into the valve, the valve should be closed by a quick turn to the left.

Picture 1: Deployment of simmilar boom

RECOVERY

Deflation

When the boom enters the ramp, boat deck or dock open the valve cap by twisting it to left, push the valve down and twist it to right to an open locked position and the air will flow out. Continue likewise with the rest. When reeling the towline onto the drum, distribute it evenly over the width of the drum. Disconnect the marker-buoy from the bridle.
When reeling the boom back in, make sure that the towboat keeps a constant, but moderate, tension at the boom-end.

Once the boom and bridle are reeled fully onto the drum, continue to apply some tension on the towline while it is reeled back. Distribute the towline evenly over the width of the drum . Thereby you will reduce the sagging down of the boom on the drum and make deployment easier the next time.

NOTE: The Boom Reel operator should observe the boom when reeled in. The Valve can accidentally position itself vertically on the boom. This happens occasionally and only means that the boom has to be reeled out and the valve put in a flat position on the boom.

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L176 - F - 500

NOFI Document name / *Dokument navn:*

DATASHEET
NOFI 800S VMT

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Drawing reference: **L176-A-100**

TECHNICAL DATA

Section Length : 40m (131,23 ft)
Freeboard Height : 800mm (31,5 in)
Skirt Depth : 940mm (37,40 in)
Feather Net between Skirt and Bottom Chain : 400mm (15,75 in)
Total Height inflated : 2140mm (84,25 in)
Weight -Approximately : 16 kg/m
Storage Volume each 40 m : Approximately 1.6m³
Buoyancy Reserve – Approximately : 450 liters/m
Reserve Buoyancy to Weight Ratio : 28:1

FABRIC

Freeboard Fabric : Heavy Duty PU/PVC Coated Polyester, 1400 g/m²
Skirt Fabric : Heavy Duty PVC Coated Polyester, 1100 g/m²
Buoyancy Chamber : Airtight PU/PVC Coated Polyester, 1000 g/m²

BUOYANCY CHAMBERS

Length : 3000mm (118,1102 in)
Diameter – Approximately : 800mm (31,4961 in)
Volume – Approximately : 1500 liters (396,25 gallons)
Valve : MONSUN XII
Number each Section (40m) : 12 off

LOAD CARRYING MEMBERS:

Bottom Tension Line, Breaking Strength : 16 mm Dyneema rope, 240,000 N
Centre Connection, Breaking Strength : 55 mm Flat Weave Webbing, 34,335 N
Top Connection, Breaking Strength : 55 mm Flat Weave Webbing, 34,335 N
Ballast : 4.5 kg/m lead rope (in addition the boom is hydro dynamically ballasted when towed)

Strong Back (2 point mooring connection) : 2 off, placed between the 2nd and 3rd buoyancy chamber on each end of the section.

OPERATIONAL DATA

Area of usage : The VMT Boom can also be used as a conventional ocean boom

Air filling : Back pack fan. Electric or hydraulic fans can also be used.
Refill off air chamber : Handholds are placed by every valve for easy access. Valves are marked with reflex and colored fabrics.

Puncture and damage on airbladder : The VMT Boom can be operated with a locally reduced freeboard on min. 500 mm. Airbladders can be replaced without using tools.

Mooring. : By Strong Back points. Additional mooring points only by connecting to bottom tension member.

Cleaning : The VMT Boom can be opened in the top and floats are taken out for easy cleaning individual, if necessary.

Marking : Sections are marked by customer number system.
Towing and operational speed : 1,2 knot before first loss (20% higher than conventional boom) in calm sea. Reference, Ohmsett test of NOFI 600S with feather net.) higher waves demands lower speed.

Wave height : Open Ocean operation: Significant wave height < 3,5 m, max. wave height 6 m.

Storing and working temperature : –30°C til +70°C

APPENDIX B

Copies of related correspondence

UAA School of Engineering
UNIVERSITY of ALASKA ANCHORAGE

3211 Providence Dr., Anchorage, Alaska 99508
Tel 907-786-1900 * Fax 907-786-1079
www.engr.uaa.alask.edu/

August 31, 2012

Alan Sorum – Maritime Operations Project Manager
Prince William Sound Regional Citizens' Advisory Council
Post Office Box 3089
Valdez, Alaska 99686

Dear Alan:

We have informally discussed prospects for involving the UAA School of Engineering , in particular a specialized graduate student under my leadership, to advance efforts to solve wave-related problems with operations at Berth 4 of the Valdez Marine Terminal. The Prince William Sound Regional Citizens Advisory Council (PWSRCAC), in particular the Port Operations and Vessel Traffic Systems (POVTS) Committee, of which I am a member, has deliberated investigations of wave problems at Berth 4 in the recent past.

I am currently leading Maria Kartezhnikova in directed study of our UAA course CE A675 Design of Ports and Harbors, which emphasizes design of breakwaters, channels, and marine terminals. Maria is advanced in her progress toward a Master of Science in Civil Engineering and a graduate certificate in Coastal, Ocean, and Port Engineering. You have my resume on file, which notes my academic credentials and specialization in port and harbor design.

I propose that I lead Maria in her CE A675 studies to complete a report as a part of the course requirements that will be submitted to the PWSRCAC POVTS Committee on its conclusion. Neither Maria or I, nor UAA, will require compensation for this work. We ask for in-kind support to gather information on the project, for review of our work, and for travel expenses for two one-day visits by Maria and I to Valdez in September and November 2012. The first visit will be for gathering information. The second visit will be for presentation of draft findings prior to submittal of a final report to you in December. I propose the following overall objective, scope of work, and schedule for our investigation.

OBJECTIVE

Our work will prepare proponents of safe operation of the Valdez Marine Terminal to conduct detailed analyses of wave-related problems at the Berth 4, to choose among practical alternatives for solving wave-related problems, and to complete final design of problem-solving measures.

SCOPE OF WORK

1. Develop a climate of wind, waves, and associated oceanographic conditions at the site (VMT Berth 4) by interviews with terminal operators, PWSRCAC specialists, and other knowledgeable persons, and by analysis of data on file.
    a. Define means to refine this climatology with field data collection and numerical modeling.

2. Define the problems associated with waves in technical terms directly related to the climate and to the various operations at the site, in consultation with terminal operators, PWSRCAC specialists, and other knowledgeable persons.
3. Develop operational and engineering design criteria for means to mitigate the problems defined.
4. Formulate conceptual alternative responses to these problems with a view toward reducing risk of spills and of failure to contain and clean up spills, if they occur, while accommodating safe and efficient terminal operations.
5. Evaluate conceptual alternatives in terms of the project operation and engineering criteria, ranking them by effectiveness, practical constructability, potential environmental concerns, and relative cost.
6. Refine the most appealing alternatives to a stage of preliminary design, including graphical illustrations with gross dimensions, descriptions of component fabrication, deployment, operation, and maintenance, and comparison of major advantages and disadvantages.
7. Recommend measures to refine the analysis with measurements and other additional data in terms that may be applied in a scope of work for a contracted specialist to continue the work through final design.
8. Present these findings to a meeting of terminal operators and PWSRCAC specialists and incorporate comments and corrections from this review into a final written report.

SCHEDULE

The following calendar of milestones describes our intended progress toward conclusion. Specific dates of visits and meetings are adjustable within the overall duration proposed. Maria's obligation to finish her report for the CE A675 course follows the UAA calendar for fall semester 2012. Her course work must be completed by 14 December 2012.

- September 4: Begin data collection
- September 19: visit Valdez Marine Terminal
- September 30: letter report summarizing findings to date
- October 31: letter report summarizing findings to date
- November 21: submit draft report for review
- November 28: visit Valdez to present draft report and discuss comments, corrections, and suggested additions
- December 14: submit final report

The work I propose will certainly further Maria's graduate education, and will at the same time accomplish worthy service in the interest of safety and efficiency of Valdez Marine Terminal operations. Refinement of our work should appropriately be accomplished by qualified engineering specialists in commercial practice, who will have a substantial head start on final design of a solution.

Please indicate your favor for this proposal in time for us to use the remaining weeks of this semester productively.

Sincerely,

Orson P. Smith

Orson P. Smith, PE, Ph.D.
Professor of Civil Engineering and Interim Dean

PRINCE WILLIAM SOUND
RCAC

Regional Citizens' Advisory Council / *"Citizens promoting environmentally safe operation of the Alyeska terminal and associated tankers."*

In Anchorage: 3709 Spenard Road / Suite 100 / Anchorage, Alaska 99503 / (907) 277-7222 / FAX (907) 277-4523
In Valdez: P.O. Box 3089 / 130 South Meals / Suite 202 / Valdez, Alaska 99686 / (907) 834-5000 / FAX (907) 835-5926

September 18, 2012

Dr. Orson Smith PhD
Ms. Maria Kartezhnikova
University of Alaska Anchorage
UAA School of Engineering
3211 Providence Drive
Anchorage, Alaska 99508

Subject: Valdez Marine Terminal Berth 4 Wave Protection Study

Dear Orson and Maria,

As Executive Director of the Prince William Sound Regional Citizens' Advisory Council, I would like to thank you for your proposal submitted to the Council addressing wave related problems that occur at the Valdez Marine Terminal. This proposal is a perfect example of the cooperative efforts we like to see take place within our region that involve multiple stakeholders.

Your proposal was reviewed by staff and forwarded to our Port Operations and Vessel Traffic System (POVTS) Committee for its consideration. The POVTS Committee has accepted your proposal and recommended funding be provided to cover travel and other miscellaneous expenses that you might incur not to exceed $2,500. Committee members were excited to see this proposal brought before them and are encouraged by this effort.

We have your project schedule in hand, understand that Alyeska Pipeline Service Company has completed its security review and has authorized your visit to the terminal. Your staff contact for this project will be Alan Sorum. Please contact him with any needs that you may have in this project.

Speaking for the Council, we look forward to seeing what Maria accomplishes with this research project and hope she will be willing to present her finding to our Board of Directors. Thank you for engaging in this worthy effort that addresses a Council concern.

Sincerely,

Mark A. Swanson
Executive Director

800.105.120918.UAAwaveproject