NSS Swiftwater NIF

BCSARA 2016 Swiftwater Rescue Testing

Summary Report

2016

By:

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Introduction:

Swiftwater Rescue is one of the disciplines which numerous volunteer Search and Rescue (SAR) teams within British Columbia are occasionally tasked with. SAR team members can take courses offered by commercial providers to obtain training and certification as Swiftwater Rescue Technicians. One aspect of Swiftwater Rescue involves using ropework and rigging techniques to secure, manoeuvre and position rescuers and watercraft while 'in-water'. Above water (aerial) rope rescue techniques are generally considered the realm of technical rope rescue, and these techniques generally use different equipment and systems than in-water systems.

While the content and techniques within Swiftwater Rescue courses appear to be relatively similar between providers, it is evident that the ropework and rigging equipment available to Swiftwater Rescue practitioners is highly diverse and not consistent in performance between brands; few standards exist. Even within the training manuals, little information and data is provided on the required performance attributes of the respective rope equipment and their respective systems.

Through a National SAR Secretariat National Initiatives Fund in 2016, the British Columbia Search and Rescue Association (BCSARA) was able to conduct some research and testing of Swiftwater Rescue systems involving rope work, particularly for in-water techniques involving watercrafts such as inflatable rafts and cata-rafts. BCSARA contracted Basecamp Innovations Ltd to conduct preliminary testing and research on currently available Swiftwater Rescue ropes and on potential 'normal' drag forces of various Swiftwater Rescue watercraft with various size loads (masses) and water speeds.

In the summer & fall of 2016, Basecamp Innovations Ltd conducted slow pull tests on various Swiftwater ropes and rope grabs, and drag force tests of various watercraft used in Swiftwater Rescue. Kootenay Swiftwater Specialists of Nelson, BC provided subject matter expertise to which equipment and materials are commonly being used within the province of BC. Nelson Search and Rescue assisted greatly with the conducting and executing of the drag force tests. The following is a summary report of the data and findings from these tests. It is important to note that the primary aim of this testing and research was to provide a baseline for which further examination of Swiftwater Rescue systems and techniques could be directed. It is not within the scope of this report to make recommendations on 'preferred techniques' or equipment for Swiftwater Rescue.

Acknowledgement:

Recognition and thanks are owed to all those who made this research and testing project happen: NSS, EMBC, BCSARA, Jim McAllister, Andrew Morrison, Chris Armstrong, Chandrima Lavoie, Larry Hanlon, Dirk Dorenbos, Heather Milligan and Nelson SAR.

Methods and Materials:

Slow Pull Tests: All slow pull tests were conducted on the *Basecamp Innovations Ltd* 135 kN hydraulic tension tester at a rate of 1000mm/min. Force over time data was recorded on a calibrated Instrunet Data Acquisition System, recording at 500 samples/sec, with FAMOS Signal Analysis Software.

Drag Force Tests: All drag force tests were conducted on Kootenay Lake, BC. Pulling of various watercraft was done using Nelson SAR's Thunderjet rescue boat with twin 150 Hp engines, made by Alexis Offshore. A six-metre boom was fitted on Port side of the rescue boat to allow the various rafts to be pulled alongside the rescue boat in non-aerated lake water. No tests were conducted to compare aerated water behind the rescue boat to the un-affected lake water. Drag force data was recorded using a calibrated Rock Exotica Enforcer Load Cell with Bluetooth connection to an i-Phone; data was recorded at three different boat speeds (5, 7 and 10 kph, or 1.4, 1.9 and 2.8 m/s respectively). Boat speed was measured with an onboard CP590 GPS, cross-calibrated using a Swoffer Model 2100 water flow meter. For each test, the range of boat speed as well as the range of force was recorded; the summary data utilized the highest force recorded during a 5 second recording period. Where practical, drag forces for different size loads (number of occupants in the raft), positioned in different locations in the raft (bow, center and stern) were recorded. It was not the objective to record drag forces of 'abnormal' forces such as fully bow-submerged rafts, or rafts positioned broadside.

Rope and Cordage Types Tested:

No photo available

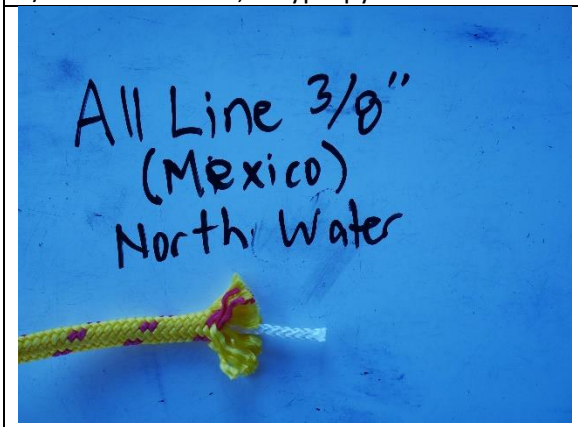
5/16"(8mm) CMC Throwline NFPA; Polypropylene sheath, Dyneema Core, NFPA Classified

5/16" Esprit River Line; Polyester sheath and blended polypropylene and Spectra core

10mm PMI WRR; Nylon sheath with polypropylene core

No photo available

3/8" Bluewater R3; Polypropylene sheath and core



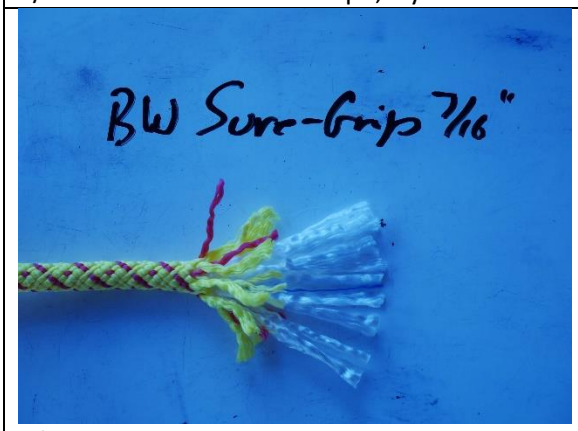
3/8" All Line (Mexico); unknown materials – product commonly supplied in BC by NorthWater

No photo available

3/8" BW Sure Grip; Variable diameter sheath strands provide 'bumpy' sheath

7/16" Bluewater HR3; Blend of Polyester and Polypropylene sheath; polypropylene core

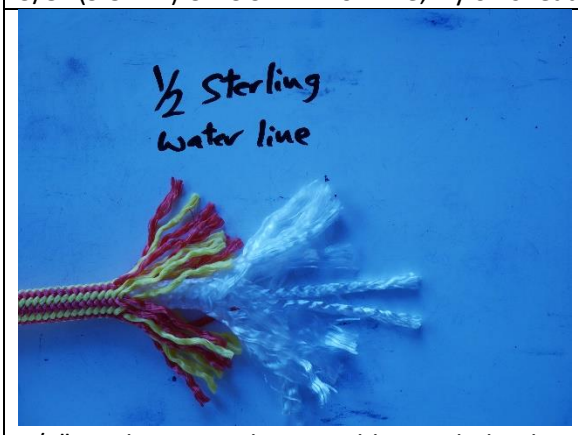
7/16" CMC River Rescue Rope; Nylon sheath with Polyolefin (polypropylene) core



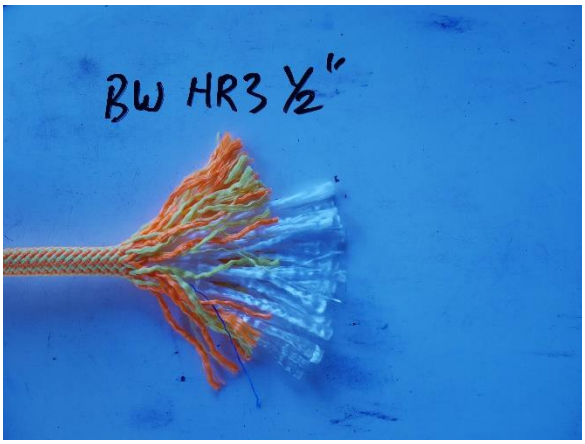
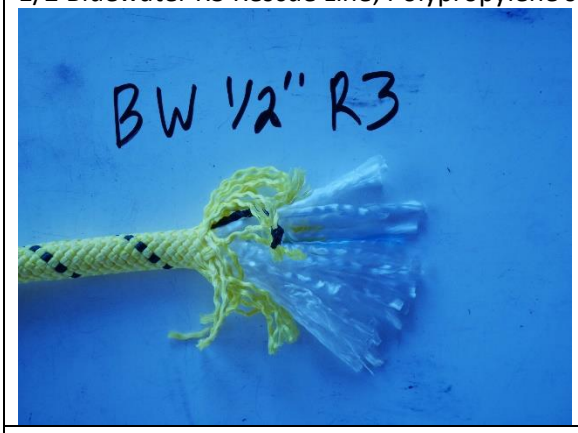
7/16" BW Sure Grip; Variable diameter sheath strands provide 'bumpy' sheath

No photo available

3/8" (9.5mm) CMC SRT Throwline; Nylon sheath with polypropylene core



1/2" Sterling Waterline; Double Braided polypropylene sheath, nylon core

 1/2" Bluewater HR3; Blend of Polyester and Polypropylene sheath; polypropylene core
1/2 Bluewater R3 Rescue Line; Polypropylene sheath and core 
5 mm Titan Cord; Dyneema core with Nylon sheath
6 mm CMC Rescue Prusik Cord; Nylon cord and sheath
7 mm CMC Rescue Prusik Cord; Nylon cord and sheath

It is important to note that for the same Swiftwater Rescue applications/techniques, that commonly available and utilized Swiftwater Rescue ropes are being used, and they have a broad range of available diameters, and are made with various construction types and materials (Polypropylene, Nylon, Polyester, Dyneema). With so many variables it becomes difficult to make any generalizations on performance or suitability for use. At best, the following slow pull tests provide an 'indicator' of performance (or lack thereof). It is ill-advised to make any extension of understanding of what is presumed to be known about the performance characteristics of 'above-water' technical rescue ropes (e.g. 11 mm nylon/polyester Static and Low Stretch ropes which conform to CI 1801-98 Standards) to those used in Swiftwater Rescue.

For comparative analysis purposes, the classic 3-wrap Prusik Hitch, using three different types of cord were used for all rope grab slow pull tests.

Swiftwater Rescue Watercrafts Tested:

1. NRS Otter 140 Self-Bailing Raft (item: 85018.01/1142); length 14’, width 7’2”; mass 57 kg

2. AIRE Tributary 9.5 HD (item: 120-001550); length 9’8”, width 5’3”, mass 31.6 kg

3. AIRE Ocelot Cataraft (discontinued model); length 14’, width 6’6”, mass 73.3 kg

4. AIRE 143E Series (item: 120-000730); length 14’, width 6’6”, mass 61.7 kg

5. Hyside Cataraft 14 (item: 166CATU1); length 14’, width 6’, mass 73.7 kg

6. Oceanid RDC (item 86114.01/1179); length 15’5”, width 48”, mass 22.7 kg

Slow Pull Tests Results, Analysis and Discussion:

Thirteen ropes, comprising of essentially four different rope diameters (5/16", 3/8", 7/16" and ½") were tested for the following parameters/conditions:

- Actual breaking strength compared to manufacturers rated breaking strength
- Figure of 8 on a bight breaking strength (most common water rescue knot)
- 5mm Titan cord 3-wrap Prusik on host rope
- 6mm CMC Rescue nylon 3-wrap Prusik on host rope
- 7mm CMC Rescue nylon 3-wrap Prusik on host rope.

Breaking Strength:

A common requirement for water rescue ropes is that they can float, which typically means they include materials which have a specific gravity of less than 1, such as Polypropylene, Polyethylene and/or Spectra/Dyneema. For strength, sometimes nylon or polyester are added but these fibres are heavier than water. Few standards exist governing the construction of water rescue ropes and therefore it is understandable that a wide variation in rope strength exists, even for the same diameter between rope brands.

The data gathered for these tests are intended to provide indications or 'quick-looks' to help direct where future efforts (research, testing, system analysis and technique/equipment development) are most required. It was not the objective of this testing project to obtain sufficiently large sample sizes per parameter to establish statistically significant values and therefore caution must be exercised to not extrapolate conclusions by assuming there is high precision in the numbers even though the data was collected with accuracy.

With such data, less attention should be given to the 'precision' of individual data points, and instead, greater value lies in examining the range of values and their pattern. That said, it appears that tying a fig 8 knot in a water rescue rope can reduce the strength by about 1/3 when compared to manufacturers rated breaking strength (obviously, this reduction is mathematically greater when the knotted breaking strength is compared to 'actual' breaking strengths).

Inevitably, a knot will generally be required at one end or the other of a water rescue rope, and therefore from a systems analysis perspective for usefulness, these values may be of greater importance than the un-knotted breaking strength. The following average knotted breaking strength values were observed (the range of values can be seen on the summary tables):

Rope Diameter	Average Fig 8 Knotted Breaking Strength
5/16"	10.3 kN (Throwropes: contain Dyneema)
3/8"	10.5 kN
7/16"	15.2 kN
½"	20.0 kN

For comparison, conventional Static and/or Low Stretch ropes (which conform to CI 1801-98 standards) used in high angle rope rescue, also have approximately a 1/3 loss in strength for fig 8 on a bight knotted breaking strength, though the manufacturers rated breaking strengths for 7/16" and ½" ropes are about 30 and 40 kN respectively. Therefore, CI 1801-98 Static and Low Stretch ropes may be expected to have knotted breaking strength values of about 20+ and 28+ kN for these diameters, whereas the water rescue ropes tested have knotted breaking strength values about 15+ and 20+ kN respectively.

There are some warnings in the literature reviewed (largely student manuals) against using water rescue ropes for high angle rope rescue work, due to insufficient strength. However, what is not evident in these manuals is direction and guidance on how much strength is required of swiftwater rope rescue applications, and where the limits of performance are with swiftwater rope rescue applications. This should be an area of further study.

Three-Wrap Prusik Tests:

For each rope type, where practical, three different types of 3-wrap Prusik hitches were tested. With Prusiks, it is important to note that the first-slip force is often very different than subsequent slip force values. This is potentially a very important factor to consider in swiftwater rescue because a rise in force on a rope system in a swiftwater environment is less likely to suddenly decline, as would typically occur in a rope system in the vertical environment, such as the fall arrest of a falling load in high angle rope rescue. In a fall arrest environment, there is a finite amount of energy in the system, and the rope system can be matched to dissipate this quantity of energy through controlled 'slippage' (e.g. force limiting) and therefore stopping distance. However, in a swiftwater rescue environment, slippage of a rope grab may add risk under certain circumstances, particularly if 'live-loads' are involved; this is less of a concern with recovery of non-live loads, such as a pinned raft.

Swiftwater rescue practitioners must therefore factor this into their risk assessment and factor this into their choice or selection of rope grab and rope system. While it is not within the scope of this testing to determine what (if any!) magnitude of slip force a rope grab in swiftwater rescue 'should' have, the aim is to provide data on currently used Prusik techniques to use as a starting point of discussion for suitability. It does not appear that the swiftwater rescue 'community' has established guidelines for rope grab performance, and these performance criteria should not be based on what currently used rope grabs perform at, but rather what is required from a systems analysis and risk assessment, for given applications of techniques.

5 mm Titan 3-Wrap Prusik:

This brand of cord uses a Dyneema core, and it is well known that Dyneema is a slippery fibre, and therefore the tails of knots are prone to slipping within knots (bends), some knots being more prone than others; these tests were no exception. Tails were observed to slip through, both in Double and Triple Fisherman's Bends. However, the force at which the tails slipped through the bends were very high, essentially approaching or matching the knotted breaking strength of the host rope when Triple-Fisherman's Bend's were used. To eliminate this mode of failure, perhaps this data is an argument in favour of using 'sewn Prusik cords' when using this type of cord/construction/material.
Titan cord Prusik slippage did occur when applied to 5/16" Throw ropes, with a first-slip value approximately half the rope's knotted breaking strength; however, subsequent and continuous slippage

occurred at values of just over 3 kN. It must be established – based on application – whether these values are acceptable or not.

For host rope diameters of 3/8" and greater, if the tails did not slip through the hitch's bend, a common failure mode was that the Prusik would 'pinch' the rope in two, at forces approaching the rope's knotted breaking strength. Depending on the objective of the swiftwater rope system, this may or may not be an advantage – however, it must be noted that while 'force-limiting rope rescue systems' are desirable in the vertical environment, this may not be the case with swiftwater rescue. As mentioned before, slippage of a rope system in a swiftwater environment may place the rescuer in a greater predicament due to repositioning of the rescuer relative to the hazard, and because the force which caused the initial slippage may not yet have subsided and therefore slippage may continue in an uncontrolled manner.

6 mm Nylon Kernmantle 3-Wrap Prusik:
Great variation in results occurred between rope types and rope diameters when gripped with 6 mm nylon 3-wrap Prusiks. A common trend was for the initial slip force to be followed by subsequent slips at lower force values, but not always (see summary table). Another trend was for initial slip force values to increase with increased host rope diameters. It could also be stated that in general, the initial slip force values were at or less than the gripping ability values of the 5 mm Titan 3-Wrap Prusiks.

Rope Diameter	6 mm Prusik 1st Slip Force Range	Knotted Breaking Strength Range
3/8"	4.9 – 9.9 kN	8.3 – 14.8 kN
7/16"	7.2 – 12.8 kN	12.4 – 14.5 kN
½"	8.4 – 11.8 kN	16.2 – 22.0 kN

The data also shows that the first-slip force range of 6 mm and 7 mm Prusiks overlaps with the range of knotted breaking strength values for both 3/8" and 7/16" ropes. Therefore, it would be an erroneous assumption that a 6 or 7mm Prusik 'will' slip on these rope diameters; a failed rope is also a possible outcome.

7 mm Nylon Kernmantle 3-Wrap Prusik:
The 7 mm Nylon 3-wrap Prusik had consistently higher initial slip force values than 6 mm nylon 3-wrap Prusiks. Without further study, it was unpredictable whether subsequent slip force values would be higher or lower than the initial slip force value; further isolation of variables – such as rope construction, stiffness, and materials, per diameter – would be required to better understand this effect, and this was not within the scope of this project. The graphs for each individual test clearly show where slips occurred, and can be used for further analysis. In none of the tests, however, did any of the Prusiks catastrophically fail (excluding tails slipping through).

Rope Diameter	7 mm Prusik 1st Slip Force Range	Knotted Breaking Strength Range
3/8"	5.6 – 10.3 kN	8.3 – 14.8 kN
7/16"	8.1 – 12.9 kN	12.4 – 14.5 kN
½"	12.3 – 13.4 kN	16.2 – 22.0 kN

Drag Force Tests Results, Analysis and Discussion:

Drag Force of Boats:

Six different water rescue boats were tested at water speeds of 5, 7 and 10 km/h. As can be expected, drag forces increased as water speed increased, and as more mass (occupants) were added. The highest recorded forces (about 1.65 kN) occurred when the raft was made to nose-dive and take on water while the occupants were positioned in the bow (i.e. with the Tributary 9.5 and Oceanid RDC boats) at a water speed of 10 km/hr. These findings are consistent with the study conducted by Chris Onions, 2013; additionally, Onions observed up to 3.4 kN raft drag forces when subjected to higher water speeds (velocity of 5.4 m/s), under similar bow nose-dive conditions.

Drag forces were lowest with each respective water rescue craft when trimmed neutrally, that is when the occupants were positioned in the centre of the craft. The highest forces – relative to the position of the occupants - occurred when they were positioned either in the bow, or at the stern, and this was dependent on which water rescue craft was being tested. In other words, with some water rescue crafts, the highest drag forces occurred when the occupants were positioned at the stern, with other crafts this occurred when the occupants were positioned in the bow. The reason for these differences was not established, and could be a topic of further study.

There did not appear to be a noticeable difference in drag force between cata-rafts and 'regular' raft shapes of similar length, with occupants centrally positioned (trimmed neutral). The smallest raft (Tributary 9.5) had the highest recorded drag forces among all water craft for centrally positioned, 2-occupant loads – the supposition for this is that the smaller craft with the same number of occupants will have a deeper draft in the water than a higher volume boat; however, this data point should not be taken out of proportion since the difference in drag force to other water rescue crafts was minimal.

Clearly, if the occupant positioning or handling of the water rescue craft creates a condition that allows the bow to nose-dive, then drag forces will rapidly climb to values substantially higher than if the craft is kept trimmed neutral or when the occupants are positioned in the stern. It was observed that the nose-diving effect can occur suddenly; this adds risk at multiple levels, not only from increasing forces on the rope systems and the boat attachments, but also to overall situational awareness (or loss thereof) from a human factor perspective.

Drag Force of Humans:

From a physics perspective, it is well understood that force on an object in water does not increase linearly with a proportional increase in water velocity, and that the force on a body in the water is dependent on the surface area being acted upon. However, it is somewhat difficult to determine the surface area of a human body being held in position in moving water by the dorsal attachment of their personal floatation device. Therefore, for these tests, a person's mass was used as the distinguishing factor. Three people, each of different mass, were tested for drag force at three different water speeds (5, 7 and 10 km/hr respectively). Interestingly, at 10 km/hr, drag forces on each person was approximately 80-90% of what their force would be of their mass in a free-hang; from this data, it is possible to estimate by extrapolation what water speed would be required to match the person's free-hang force. Each participant in the tests commented that their ability to properly breathe at 10 km/hr was noticeably difficult, and subjectively, they felt that their ability to perform additional physical effort (i.e. live bait technique) would be substantially adversely affected.

Summary:

The data and observations obtained from these indicator tests show high variation in the performance of water rescue ropes, both within and between specific rope diameters. Additionally, there appears to be high variation in the performance of 3-wrap Prusiks when used with these ropes, particularly between brands, but less so for a given brand. In other words, knowledge of Prusik behaviour about one brand of rope and Prusik cannot necessarily be applied as an extension of knowledge to other brands of similar diameter without further examination. Until such time whereby further investigation of the effects of variations in construction and materials of water rescue ropes are made, generalizations about the performance of swiftwater rope rescue systems are at best, difficult. Therefore, unless specific testing of a specific brand of rope and associated rope grabs is made to understand system performance and limitations, a greater level of conservative approach is warranted.

From the data gathered on ropes, Prusiks, boat and human drag forces, it is possible to establish certain constraints around which rope(s) and Prusik combinations will provide approximate levels of performance, but it must yet be established whether from a risk analysis perspective, these levels of performance meet the desired level of safety, particularly for live-load applications.

Other than a somewhat generic requirement that water rescue ropes must float, the referenced literature does not seem to make distinctions between rope diameters, respective constructions and preferred materials for given swiftwater rope rescue techniques. There is almost an unstated assumption that any of the combinations of rope and rope grab will work for the described techniques, yet it is clear that substantial variation in performance exists. Considering this, it would be of value for the swiftwater rescuer discipline/community to establish preferred/required performance criteria for the various swiftwater rope techniques and systems to better understand what level of safety is being worked with.

For non-live loads, the lack of knowledge of various swiftwater rope and rope grab combination may not appear to present a hazard, since the failure of such a system may not jeopardize human life. However, the same equipment is being used for both non-live and live load applications in swiftwater rescue, therefore it would be prudent for swiftwater rescue practitioners to have improved comparative analysis of various swiftwater rope systems.

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Literature and References Reviewed:

Smith, Gordon and Stephen R. Allen; Force on a Highline Caused by River Flow; International Technical Rescue Symposium, Peublo CO, USA, 2009.

Onions, Chris; Highline Rescue Boat Systems – A study of the load created by tethered rescue boats with respect to stream velocity, trim and hull size. Research at the University of Central Lancashire. 2013

Rescue Canada; Swiftwater/Safety Rescue Technician Student Manual; 2013

Rescue 3 International; Swiftwater and Flood Rescue Technician Student Manual; 2016

Phillips, Ken; NPS Swiftwater Rescue Training Manual; 2012

CMC Rescue Inc; website – water rescue ropes.

Esprit Ropes website – water rescue ropes.

Bluewater Ropes website – water rescue ropes

Sterling Ropes website -water rescue ropes

Appendix A:

BASECAMP INNOVATIONS LTD, 2016

NIF 2016 - EMBC & BCSARA

Swiftwater Rescue Systems Slow Pull Tests				5 mm		CMC		CMC		knotted	avg	avg
Rope Type	MRBS (kN)	Avg BS (kN)	Fig 8 BS (kN)	Titan 3W (kN)	Comments/Observations	6mm 3W (kN)	Comments/Observations	7mm 3W (kN)	Comments/Observations	bs	mrbs	knotted
5/16"(8mm) CMC Throwline NFPA	14.0	18.6	10.1	n/a	n/a	3.7	Prusik slipped	n/a	n/a	0.72	14.7	10.3
5/16" Esprit River Line	14.2	15.3	10.1	5.4	Prusik slipped; kept slipping with ~ 3.3 kN resistance	5.6	1st slip ~ 3.6 kN, then ~4, then ~4.6, then ~5.2, then 5.6 kN	6.2	1st slip ~ 4.3kN, then ~4.4, then ~4.7, then 5.2, then ~6.2 kN	0.71		
10mm PMI WRR	16.0	15.5	10.7	12.8	Prusik pinched rope in two	11.8	1st slip ~ 7.5kN; 2nd ~ 9kN; 3rd ~ 10 kN; termination failed	12.2	1st slip ~ 7.5 kN; 2nd ~ 10 kN; clove hitch termination failed	0.67		
3/8" Bluewater R3	15.0	17.8	14.8	12.4	Prusik pinched rope in two	9.9	Prusik failed rope sheath at 9.9 kN; core at ~6 kN	10.3	Prusik failed rope sheath at 10.3 kN; core at ~7 kN	0.99	12.6	10.5
3/8" All Line (Mexico)	?	10.9	10.2	6.9	Prusik failed rope sheath at 6.9 kN	5.1	Prusik slipped	5.6	1st slip ~ 5.6 kN; subsequent slips ~ 3-4 kN			
3/8" BW Sure Grip	9.7	11.8	8.4	n/a	n/a	5.1	1st slip ~ 5.1; subsequent slips ~2.2-2.8 kN	6.5	1st slip ~ 6.5 kN; subsequent slips ~ 3.5 kN	0.87		
3/8" (9.5mm) CMC SRT Throwline	13.0	13.0	8.3	n/a	n/a	4.9	1st slip ~ 4.9 kN; subsequent slips ~ 2.2-2.8 kN	5.8	1st slip ~ 5.8 kN; subsequent slips ~ 3-3.2	0.64		
7/16" Bluewater HR3	17.3	19.7	12.4	10.0	Prusik didn't slip; clove hitch termination failed	7.2	Prusik slipped; regrip ~ 3.5 kN; reslip ~ 6.5 kN	9.0	Prusik slipped; subsequent slips ~ 6.5 kN	0.72	19.1	15.2
7/16" CMC River Rescue Rope	25.0	23.0	18.8	13.4	Prusik gripped but double fisherman pulled through	12.8	1st slip ~9.3kN; then ~11.5 kN, then pinched rope in two	12.9	Prusik slipped twice, then failed sheath ~ 12.3 kN	0.75		
7/16" BW Sure Grip	15.1	19.6	14.5	11.7	Prusik pinched rope in two	7.8	1st slip ~ 7.8 kN; kept slipping with ~ 3.5 kN resistance	8.1	1st slip ~ 8.1 kN; kept slipping with ~ 4.5-5 kN resistance	0.96		
1/2" Sterling Waterline	25.6	29.9	21.9	12.5	Prusik gripped but double fisherman pulled through	8.4	1st slip ~ 8.4 kN; subsequent slips at ~ 7 kN with ~ 4kN regrip	13.4	failed rope sheath at peak force	0.85	21.9	20.0
1/2" Bluewater HR3	22.2	26.8	22.0	17.2	Prusik gripped but triple fisherman pulled through	11.2	1st slip ~ 11.2 kN; subsequent slips ~ 5.5-7 kN	12.3	1st slip ~ 12.3 kN; subsequent slips ~ 6-8.5 kN	0.99		
1/2 Bluewater R3 Rescue Line	17.8	24.9	16.2	16.3	Prusik failed rope at standing part exiting hitch	11.8	Rope sheath failed ~ 11.8 kN; then core failed ~ 10 kN	13.1	Rope sheath failed ~ 13 kN; then core failed ~ 8 kN	0.91		

Rope Description (all 2016 models):

Bluewater Sure Grip: Variable diameter sheath strands provide 'bumpy' sheath surface; polypropylene core
Bluewater HR3: Blend of Polyester and Polypropylene sheath; polypropylene core
Bluewater R3: Polypropylene sheath and core
CMC Rescue NFPA* Throwline: Polypropylene sheath Dyneema core (NFPA classified)
CMC (New England) SRT Throwline: Nylon sheath with polypropylene core.
CMC Rescue (New England) River Rescue Rope: Nylon sheath with Polyolefin core. Advertised as "compatible with Prusik Hitches, ascenders, pulleys and other rescue hardware."
Esprit River Line: Polyester sheath and blended polypropylene and Spectra core
PMI Water Rescue Rope: Nylon sheath with polypropylene core
Sterling Waterline: Double Braided high tenacity polypropylene construction

* NFPA Throwline Performance Requirements: Min Breaking Strength not less than 13 kN; min 7mm max 9.5; floating

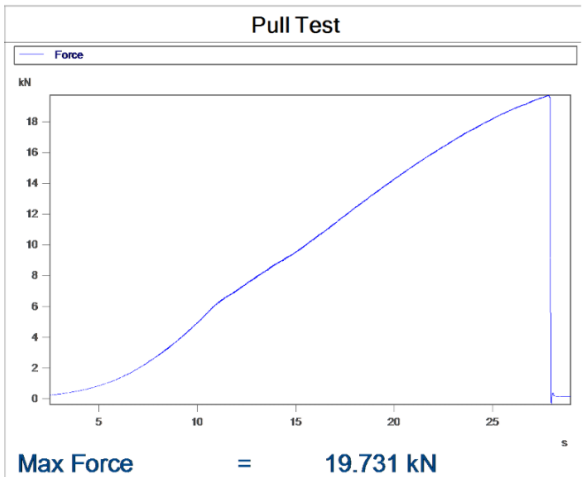
Cord Description (all 2016 models):

5 mm Titan Cord; nylon sheath, Dyneema Core
6 mm CMC Rescue Prusik Cord; Nylon sheath and core
7 mm CMC Rescue Prusik Cord; Nylon sheath and core

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

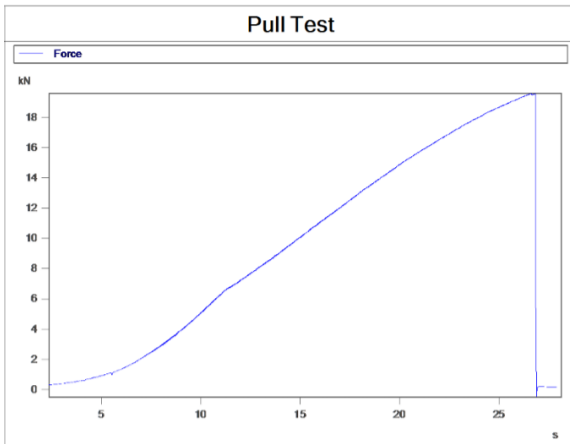
Test 1:



Max Force = 19.731 kN
Force Sample Rate = 500 Hz

18/08/2016 13:57:56
7/16" BW HR3 Baseline Strength Test

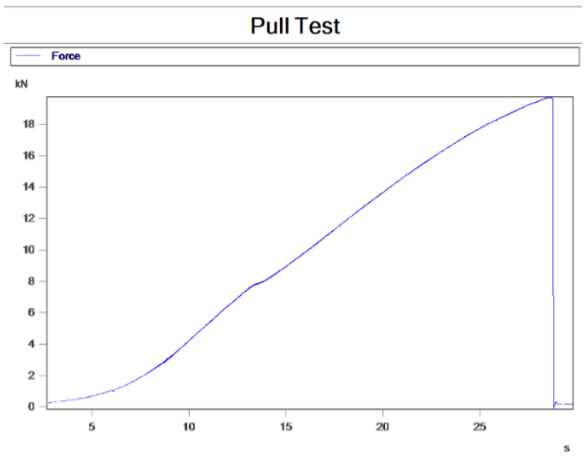
Test 2:



Max Force = 19.594 kN
Force Sample Rate = 500 Hz

18/08/2016 14:08:41
7/16" BW HR3 Baseline Strength Test

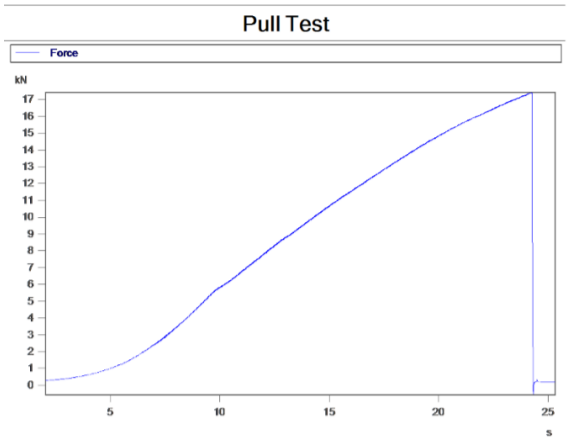
Test 3:



Max Force = 19.757 kN
Force Sample Rate = 500 Hz

18/08/2016 14:15:20
7/16" BW HR3 Baseline Strength Test

Test 4:



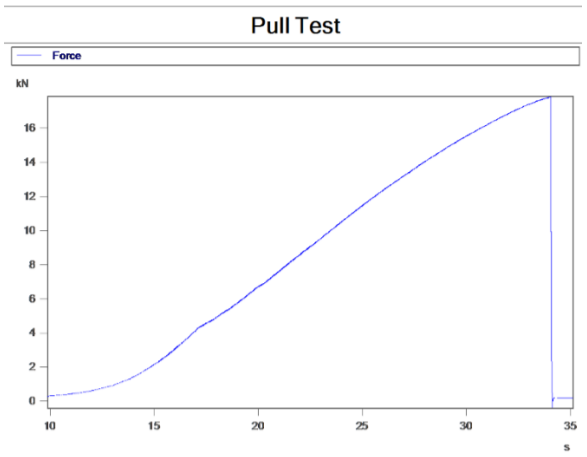
Max Force = 17.420 kN
Force Sample Rate = 500 Hz

18/08/2016 14:25:01
3/8" BW R3 Baseline Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 5:

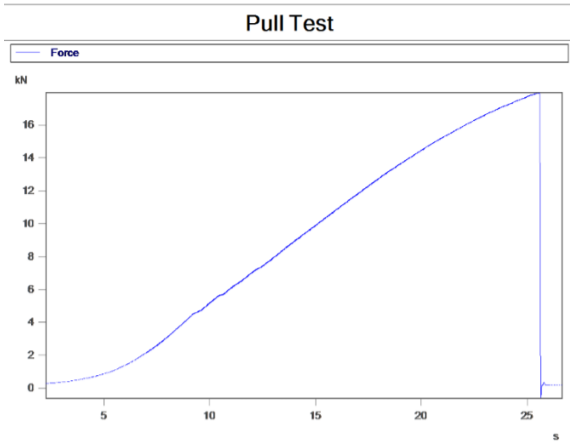


Max Force = 17.877 kN
Force Sample Rate = 500 Hz

18/08/2016 14:29:38

3/8" BW R3 Baseline Strength Test

Test 6:

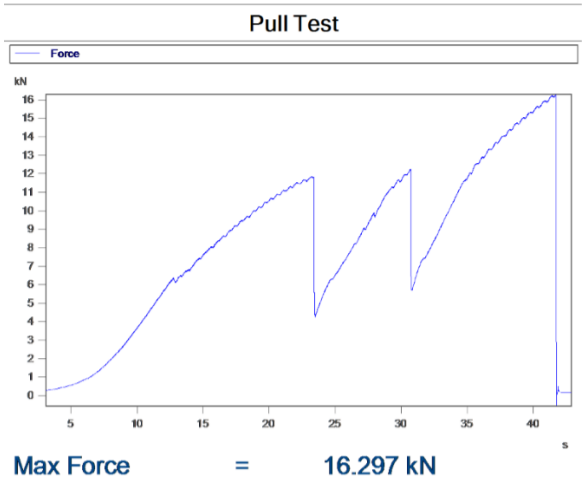


Max Force = 17.969 kN
Force Sample Rate = 500 Hz

18/08/2016 14:34:35

3/8" BW R3 Baseline Strength Test

Test 7:

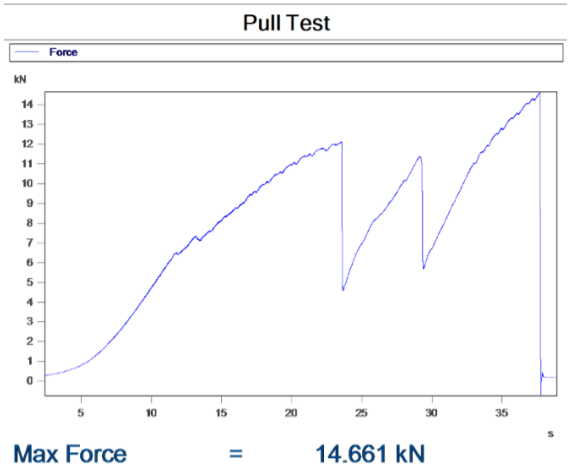


Max Force = 16.297 kN
Force Sample Rate = 500 Hz

18/08/2016 14:43:29

10mm PMI Water Rescue Rope Baseline Strength Test

Test 8:



Max Force = 14.661 kN
Force Sample Rate = 500 Hz

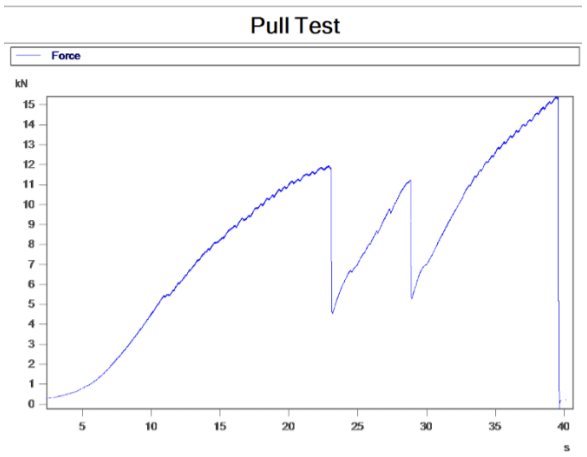
18/08/2016 14:48:50

10mm PMI Water Rescue Rope Baseline Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 9:

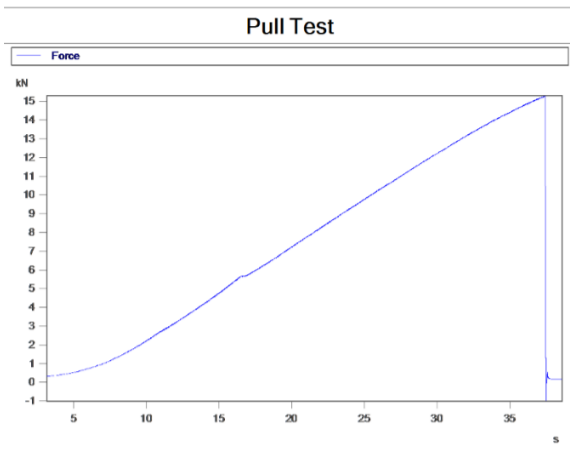


Max Force = 15.422 kN
Force Sample Rate = 500 Hz

18/08/2016 14:55:20

10mm PMI Water Rescue Rope Baseline Strength Test

Test 10:

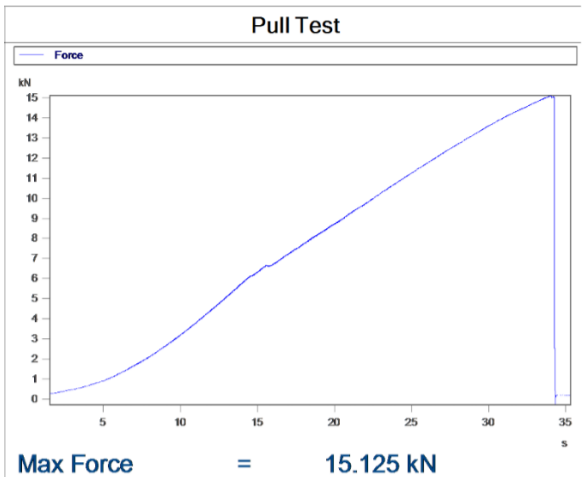


Max Force = 15.303 kN
Force Sample Rate = 500 Hz

18/08/2016 15:03:11

3/8 Esprit River Line Baseline Strength Test

Test 11:

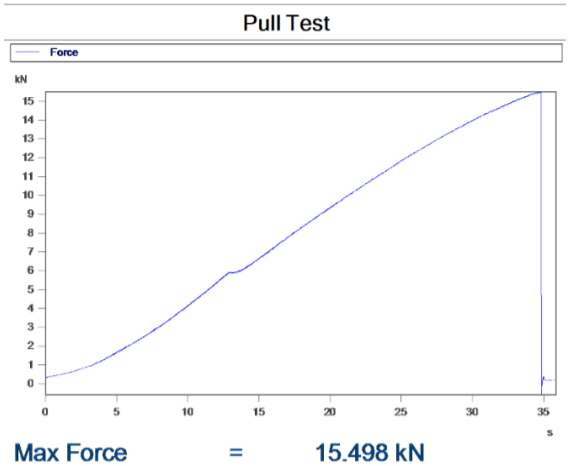


Max Force = 15.125 kN
Force Sample Rate = 500 Hz

18/08/2016 15:18:44

5/16 Esprit River Line Baseline Strength Test

Test 12:



Max Force = 15.498 kN
Force Sample Rate = 500 Hz

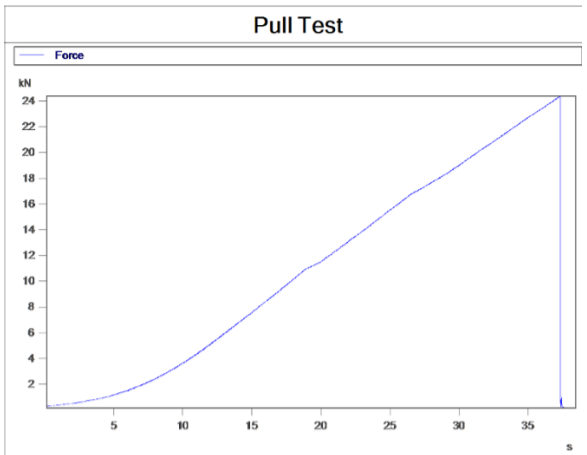
18/08/2016 15:26:29

5/16 Esprit River Line Baseline Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 13:

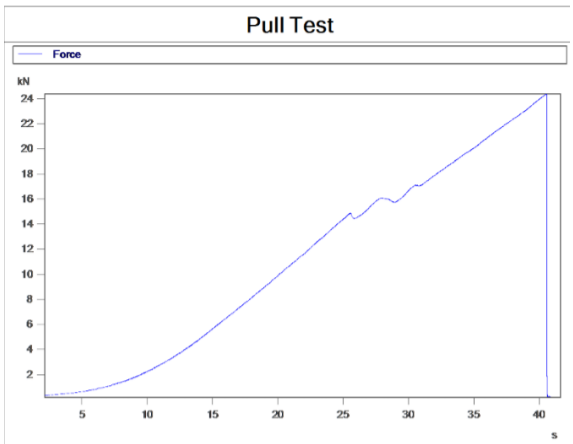


Max Force = 24.392 kN
Force Sample Rate = 500 Hz

18/08/2016 15:45:45

7/16 CMC River Rescue Rope Baseline Strength Test

Test 14:

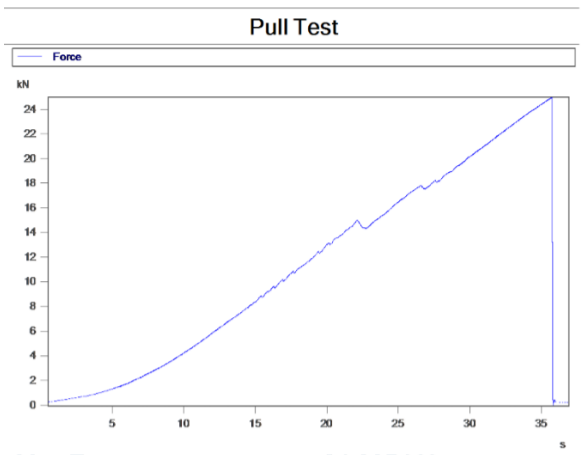


Max Force = 24.386 kN
Force Sample Rate = 500 Hz

18/08/2016 15:50:48

7/16 CMC River Rescue Rope Baseline Strength Test

Test 15:

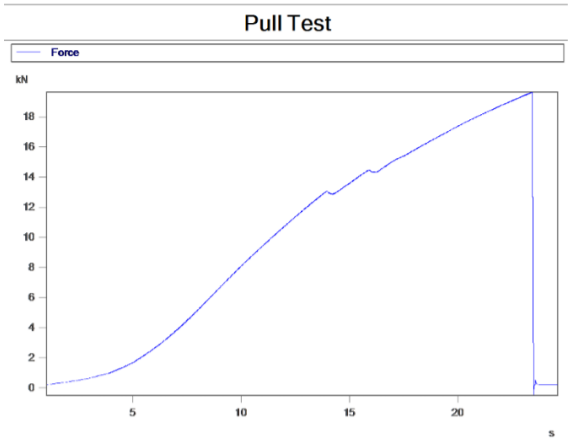


Max Force = 24.985 kN
Force Sample Rate = 500 Hz

18/08/2016 15:56:44

7/16 CMC River Rescue Rope Baseline Strength Test

Test 16:



Max Force = 19.654 kN
Force Sample Rate = 500 Hz

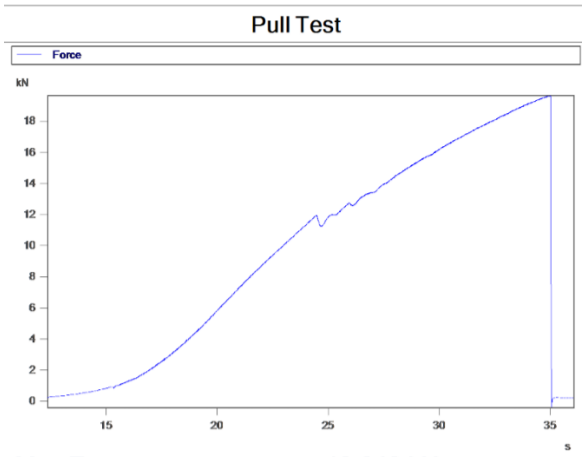
18/08/2016 16:05:20

7/16 BW Sure Grip Baseline Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 17:

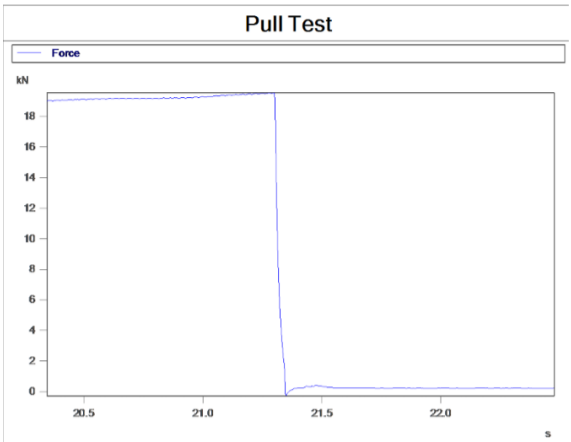


Max Force = 19.642 kN
Force Sample Rate = 500 Hz

18/08/2016 16:10:30

7/16 BW Sure Grip Baseline Strength Test

Test 18:

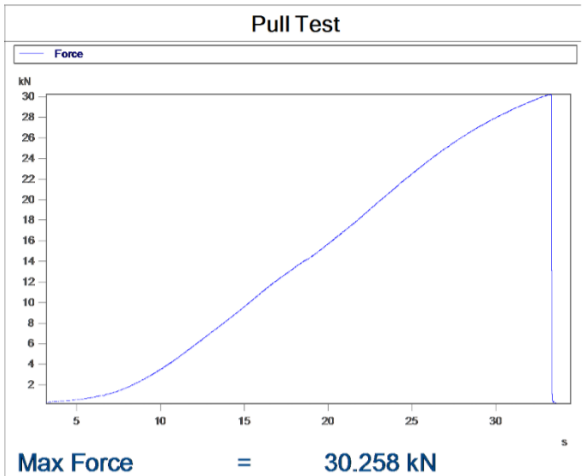


Max Force = 19.552 kN
Force Sample Rate = 500 Hz

18/08/2016 16:19:49

7/16 BW Sure Grip Baseline Strength Test

Test 19:

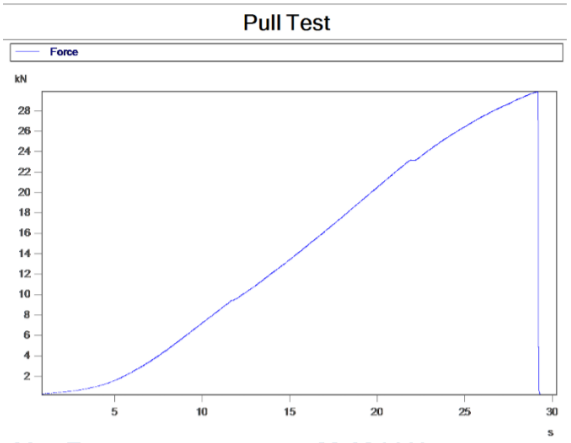


Max Force = 30.258 kN
Force Sample Rate = 500 Hz

18/08/2016 16:27:36

1/2 Sterling Waterline Baseline Strength Test

Test 20:



Max Force = 29.894 kN
Force Sample Rate = 500 Hz

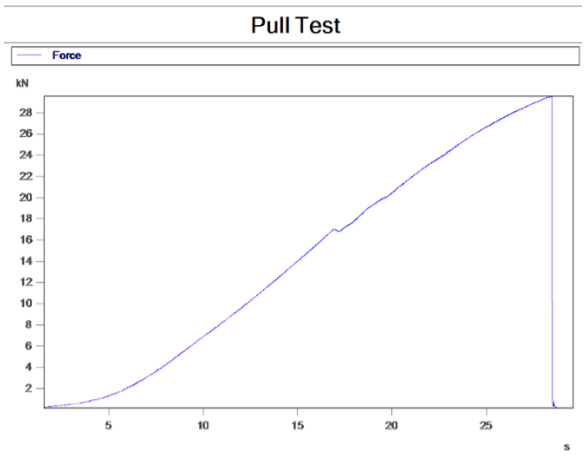
18/08/2016 16:33:23

1/2 Sterling Waterline Baseline Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 21:

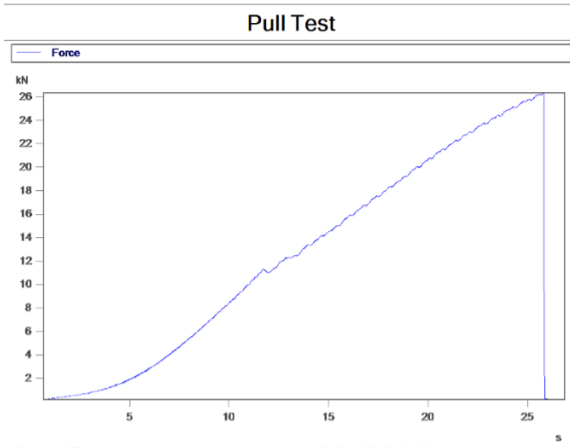


Max Force = 29.576 kN
Force Sample Rate = 500 Hz

18/08/2016 16:39:02

1/2 Sterling Waterline Baseline Strength Test

Test 22:

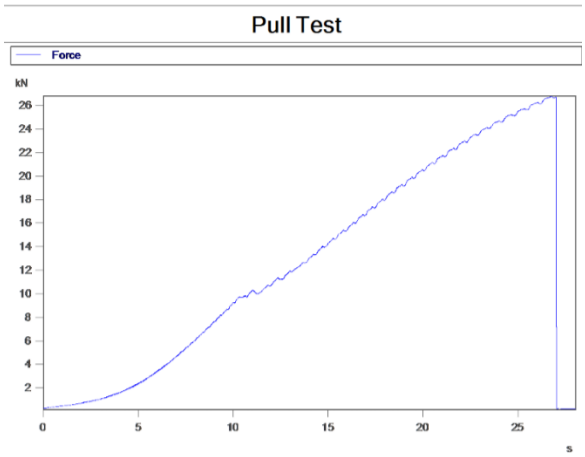


Max Force = 26.339 kN
Force Sample Rate = 500 Hz

18/08/2016 16:46:27

1/2 Bluewater HR3 Baseline Strength Test

Test 23:

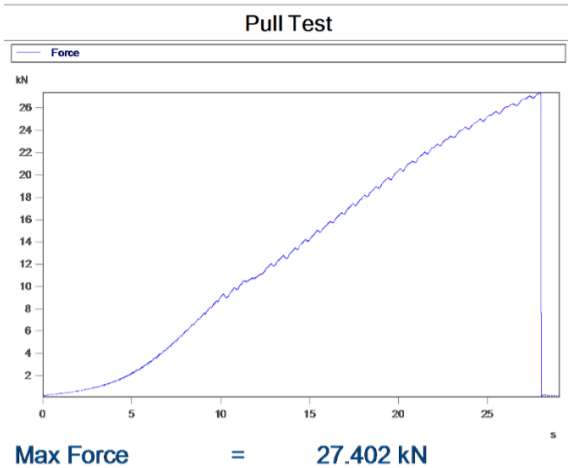


Max Force = 26.810 kN
Force Sample Rate = 500 Hz

18/08/2016 16:52:19

1/2 Bluewater HR3 Baseline Strength Test

Test 24:



Max Force = 27.402 kN
Force Sample Rate = 500 Hz

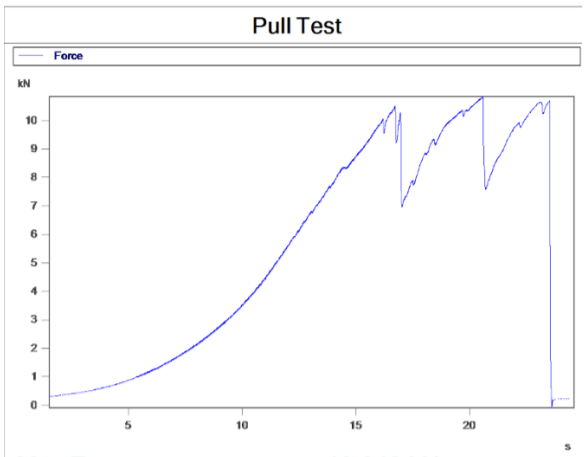
18/08/2016 16:58:37

1/2 Bluewater HR3 Baseline Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 25:

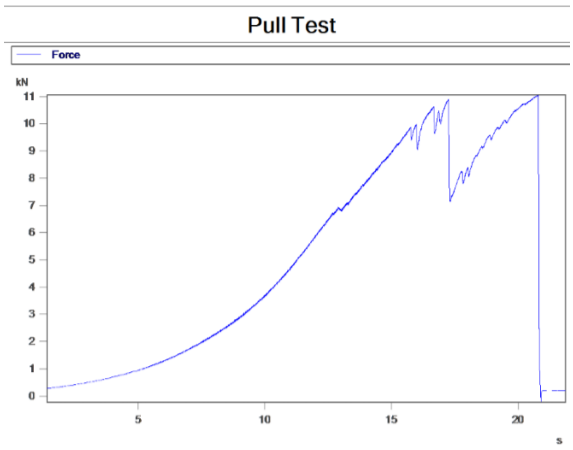


Max Force = 10.846 kN
Force Sample Rate = 500 Hz

18/08/2016 17:57:29

All Line 3/8" (Mexico) Baseline Strength Test

Test 26:

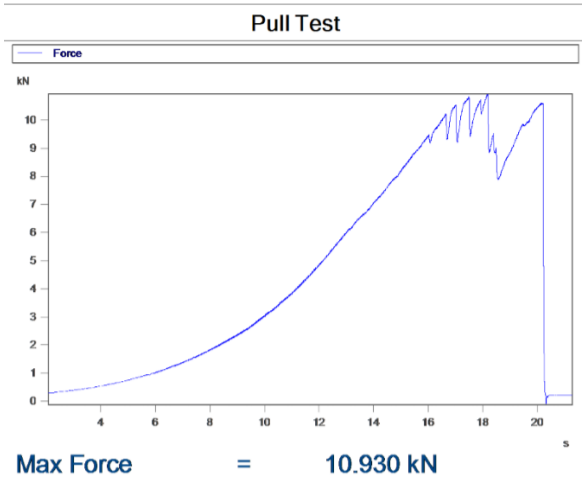


Max Force = 11.061 kN
Force Sample Rate = 500 Hz

18/08/2016 18:06:37

All Line 3/8" (Mexico) Baseline Strength Test

Test 27:

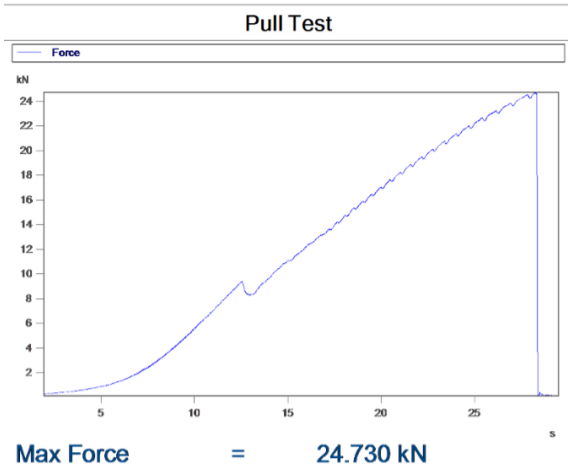


Max Force = 10.930 kN
Force Sample Rate = 500 Hz

18/08/2016 18:12:04

All Line 3/8" (Mexico) Baseline Strength Test

Test 28:



Max Force = 24.730 kN
Force Sample Rate = 500 Hz

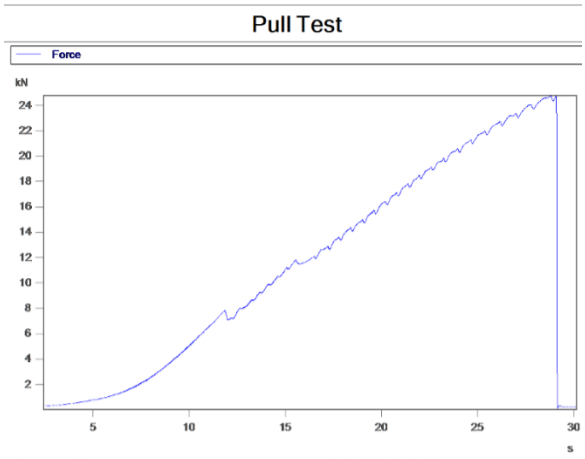
18/08/2016 18:20:49

Bluewater R3 Rescue 1-2 Baseline Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 29:

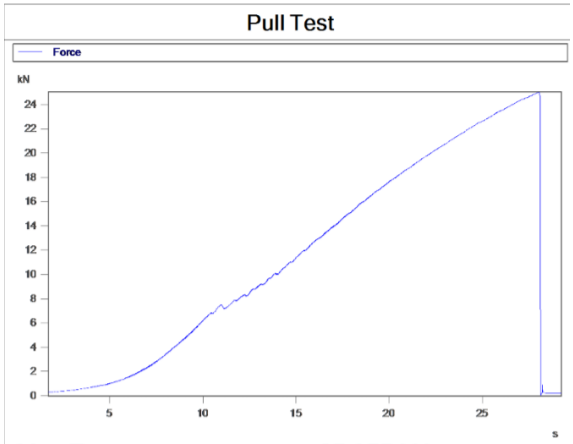


Max Force = 24.768 kN
Force Sample Rate = 500 Hz

18/08/2016 18:25:51

Bluewater R3 Rescue 1-2 Baseline Strength Test

Test 30:

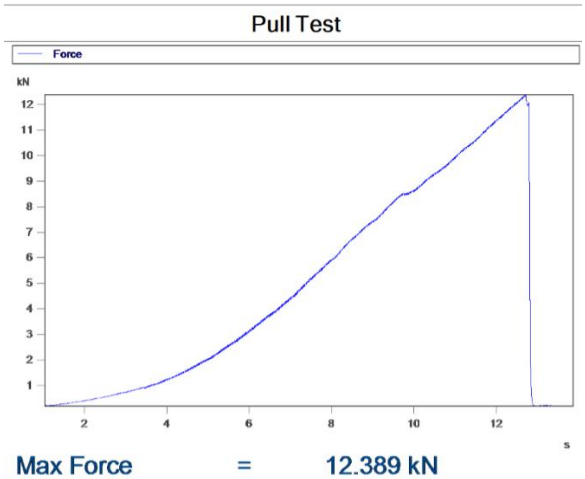


Max Force = 25.055 kN
Force Sample Rate = 500 Hz

18/08/2016 18:32:18

Bluewater R3 Rescue 1-2 Baseline Strength Test

Test 31:

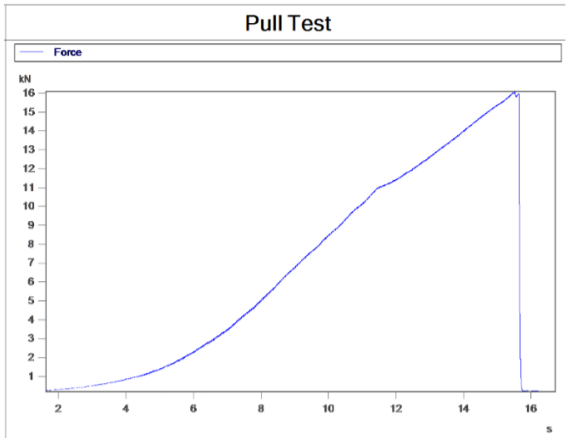


Max Force = 12.389 kN
Force Sample Rate = 500 Hz

18/08/2016 18:48:42

Bluewater HR3 Rescue 7/16 Knotted Strength Test

Test 32:



Max Force = 16.094 kN
Force Sample Rate = 500 Hz

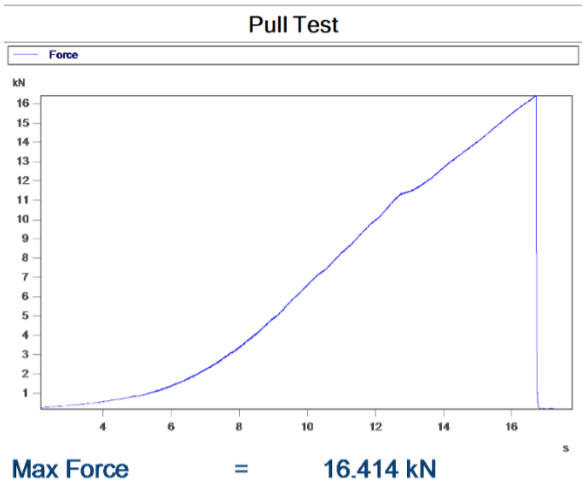
18/08/2016 18:57:10

Bluewater HR3 Rescue 7/16 Knotted Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 33:

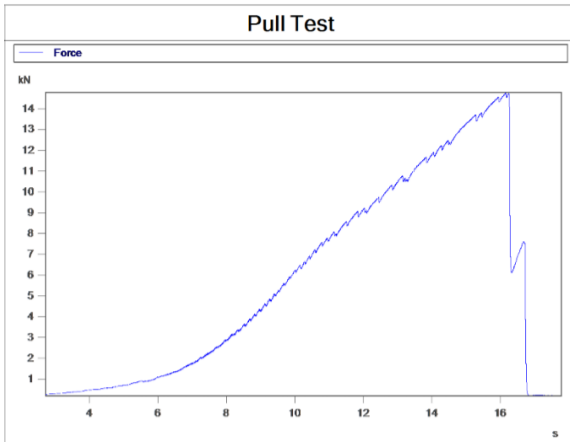


Max Force = 16.414 kN
Force Sample Rate = 500 Hz

18/08/2016 19:00:49

Bluewater HR3 Rescue 7/16 Knotted Strength Test

Test 34:

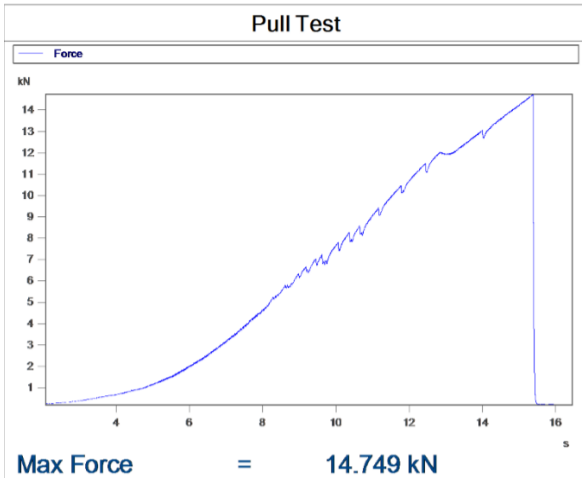


Max Force = 14.777 kN
Force Sample Rate = 500 Hz

18/08/2016 19:06:57

Bluewater R3 Rescue 3/8 Knotted Strength Test

Test 35:

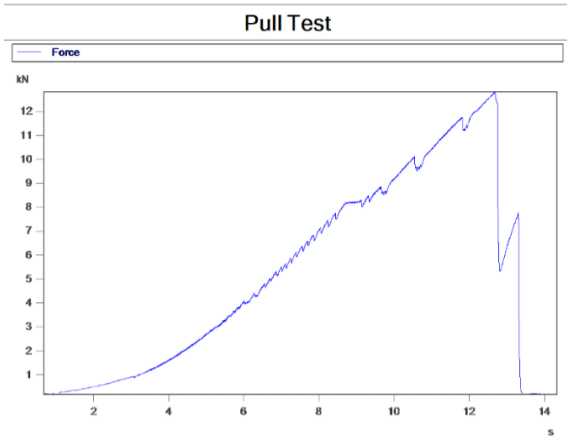


Max Force = 14.749 kN
Force Sample Rate = 500 Hz

18/08/2016 19:10:39

Bluewater R3 Rescue 3/8 Knotted Strength Test

Test 36:



Max Force = 12.819 kN
Force Sample Rate = 500 Hz

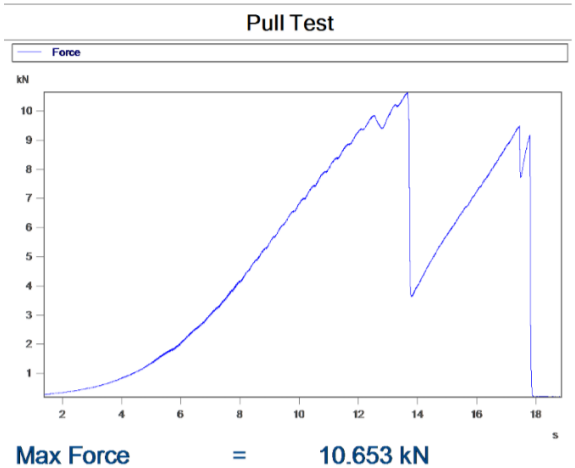
18/08/2016 19:14:14

Bluewater R3 Rescue 3/8 Knotted Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 37:

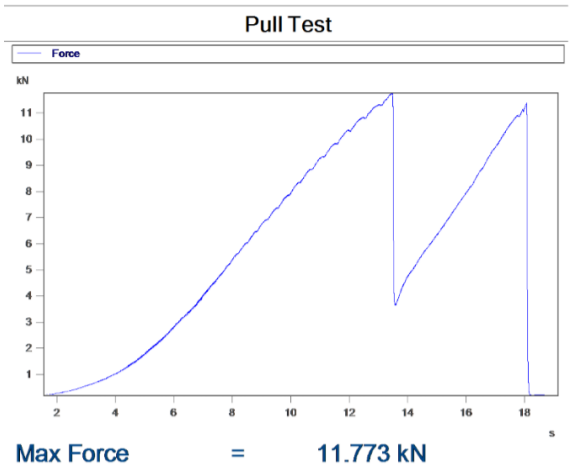


Max Force = 10.653 kN
Force Sample Rate = 500 Hz

18/08/2016 19:20:31

PMI 10 mm WRR Knotted Strength Test

Test 38:



Max Force = 11.773 kN
Force Sample Rate = 500 Hz

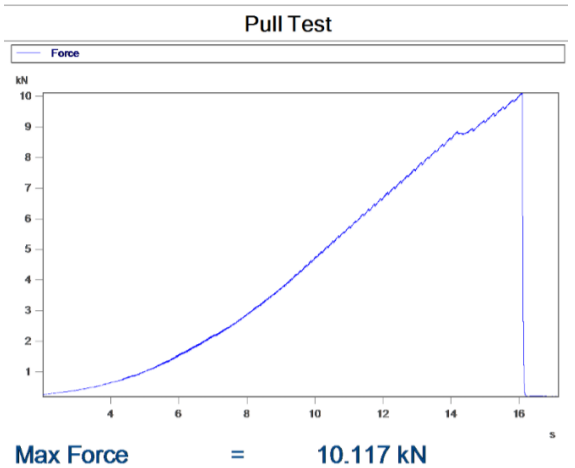
18/08/2016 19:25:22

PMI 10 mm WRR Knotted Strength Test

Test 39:

No graph available

Test 40:



Max Force = 10.117 kN
Force Sample Rate = 500 Hz

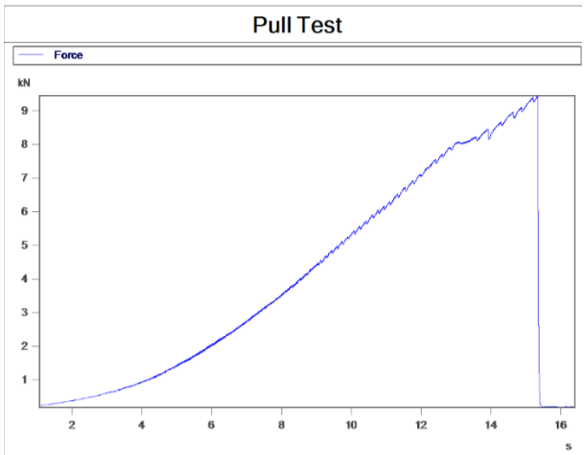
18/08/2016 19:34:15

Esprit 5/16 Riverline Knotted Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test41:

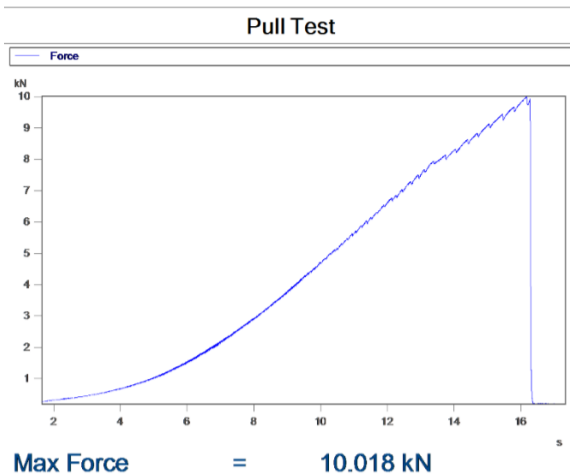


Max Force = 9.455 kN
Force Sample Rate = 500 Hz

18/08/2016 19:38:17

Esprit 5/16 Riverline Knotted Strength Test

Test 42:

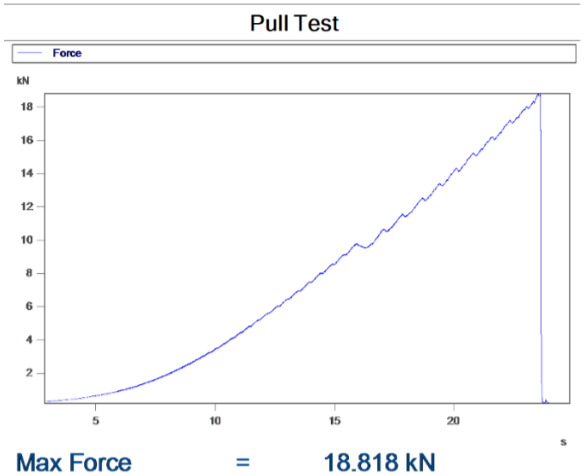


Max Force = 10.018 kN
Force Sample Rate = 500 Hz

18/08/2016 19:41:45

Esprit 5/16 Riverline Knotted Strength Test

Test 43:

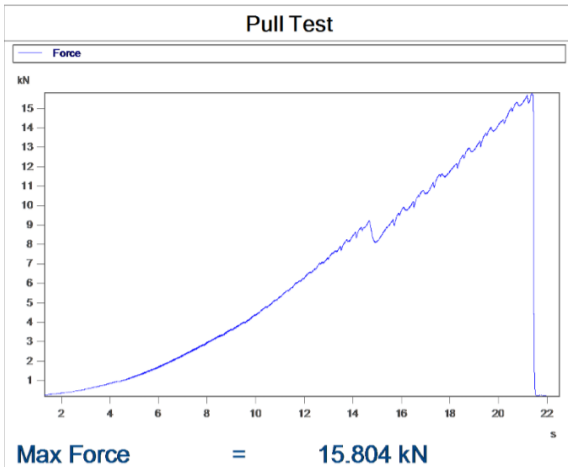


Max Force = 18.818 kN
Force Sample Rate = 500 Hz

18/08/2016 19:47:55

CMC 7/16 River Rescue Rope Knotted Strength Test

Test 44:



Max Force = 15.804 kN
Force Sample Rate = 500 Hz

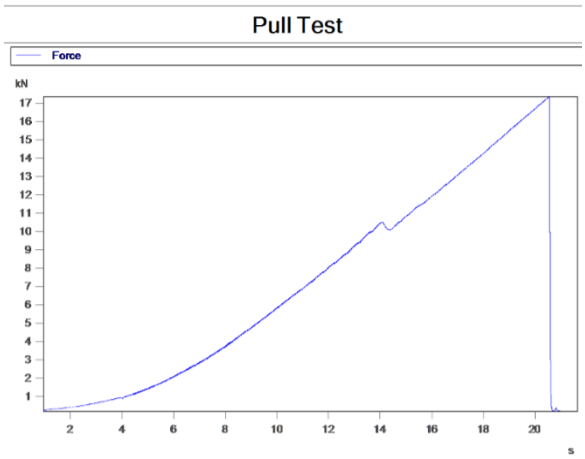
18/08/2016 19:51:29

CMC 7/16 River Rescue Rope Knotted Strength Test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 45:

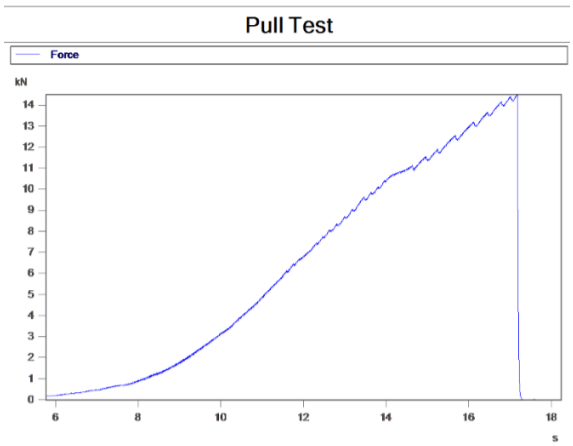


Max Force = 17.372 kN
Force Sample Rate = 500 Hz

18/08/2016 19:55:38

CMC 7/16 River Rescue Rope Knotted Strength Test

Test 46:

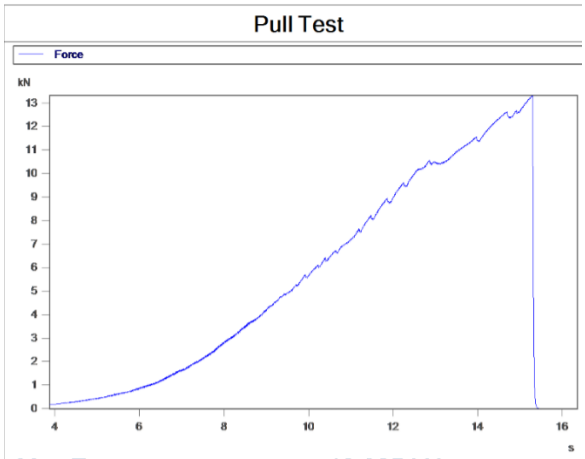


Max Force = 14.495 kN
Force Sample Rate = 500 Hz

19/08/2016 09:04:10

Bluewater Sure Grip 7/16 knotted strength test

Test 47:

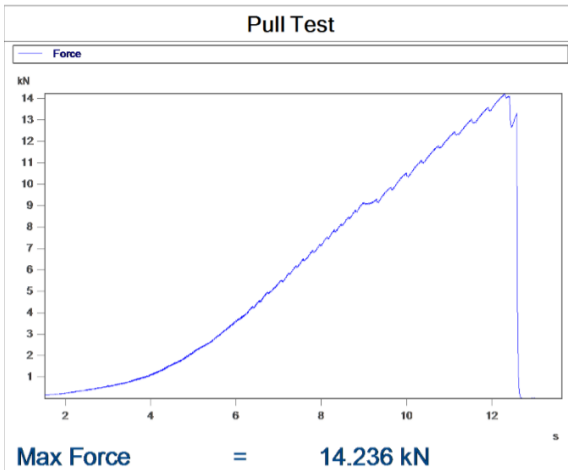


Max Force = 13.325 kN
Force Sample Rate = 500 Hz

19/08/2016 09:10:02

Bluewater Sure Grip 7/16 knotted strength test

Test 48:



Max Force = 14.236 kN
Force Sample Rate = 500 Hz

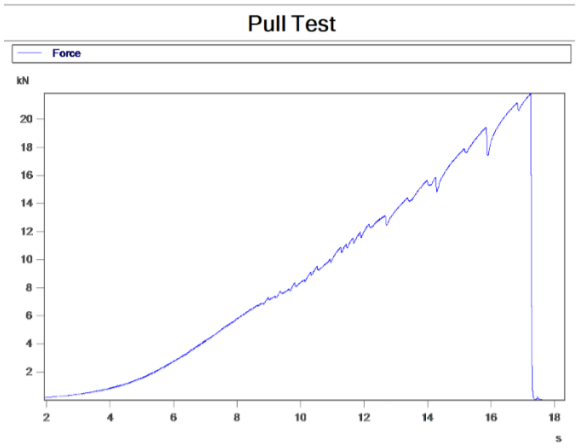
19/08/2016 09:14:13

Bluewater Sure Grip 7/16 knotted strength test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 49:

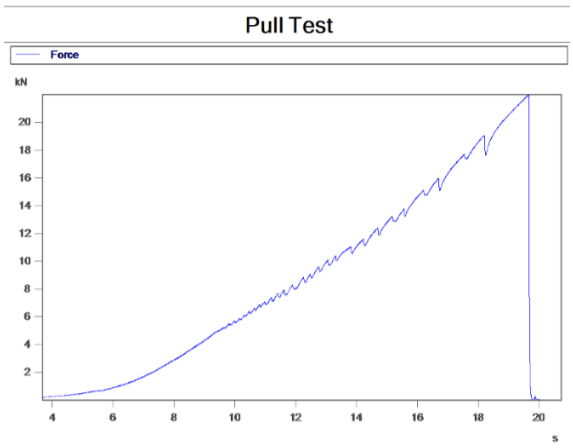


Max Force = 21.854 kN
Force Sample Rate = 500 Hz

19/08/2016 09:18:35

Sterling Waterline 1-2 knotted strength test

Test 50:

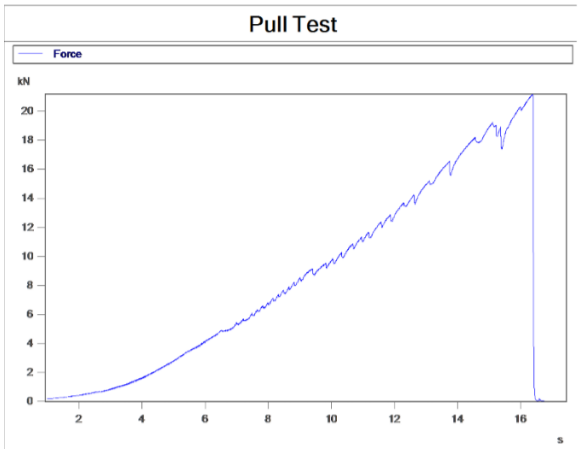


Max Force = 21.993 kN
Force Sample Rate = 500 Hz

19/08/2016 09:22:06

Sterling Waterline 1-2 knotted strength test

Test 51:

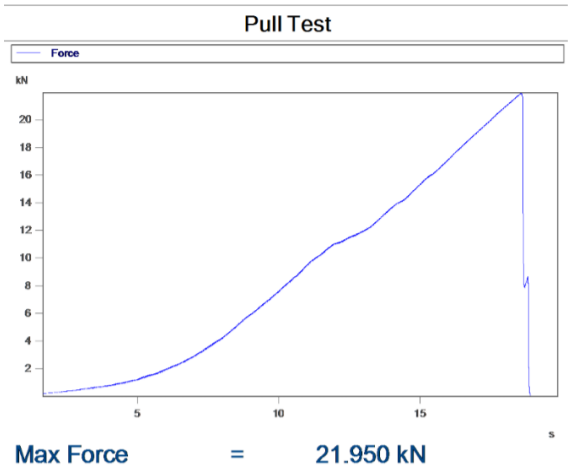


Max Force = 21.181 kN
Force Sample Rate = 500 Hz

19/08/2016 09:25:47

Sterling Waterline 1-2 knotted strength test

Test 52:



Max Force = 21.950 kN
Force Sample Rate = 500 Hz

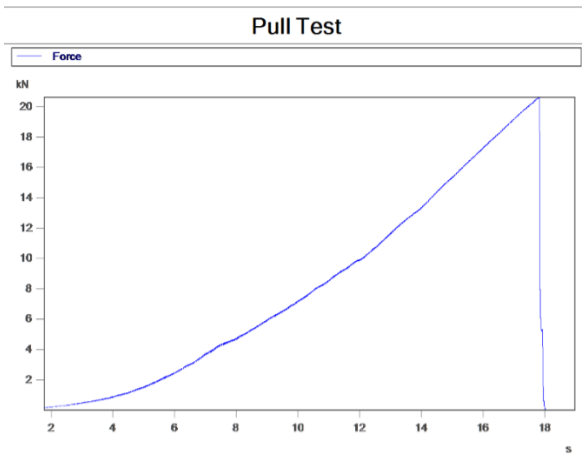
19/08/2016 09:31:07

Bluewater HR3 1-2 knotted strength test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 53:

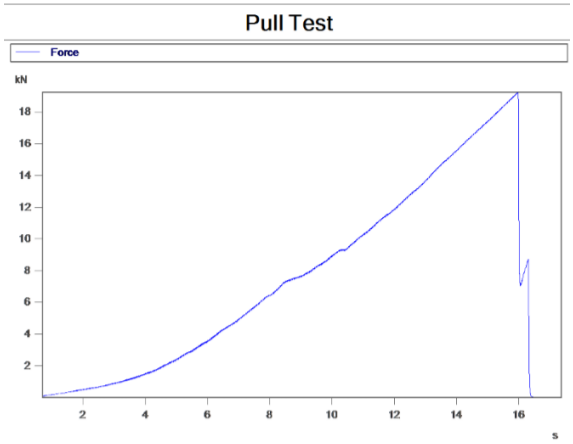


Max Force = 20.614 kN
Force Sample Rate = 500 Hz

19/08/2016 09:35:06

Bluewater HR3 1-2 knotted strength test

Test 54:

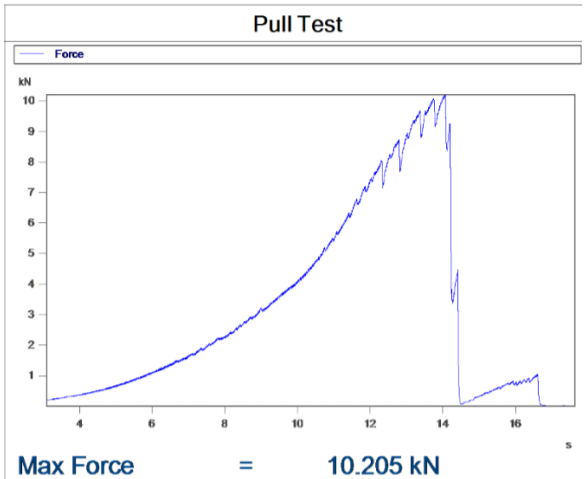


Max Force = 19.255 kN
Force Sample Rate = 500 Hz

19/08/2016 09:38:02

Bluewater HR3 1-2 knotted strength test

Test 55:

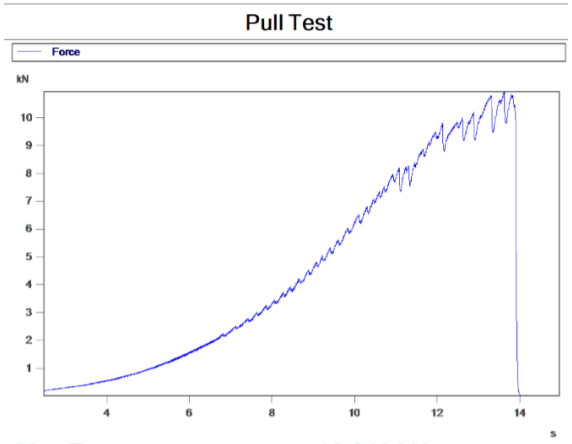


Max Force = 10.205 kN
Force Sample Rate = 500 Hz

19/08/2016 09:42:23

3/8" All Line (Mexico) knotted strength test

Test 56:



Max Force = 10.940 kN
Force Sample Rate = 500 Hz

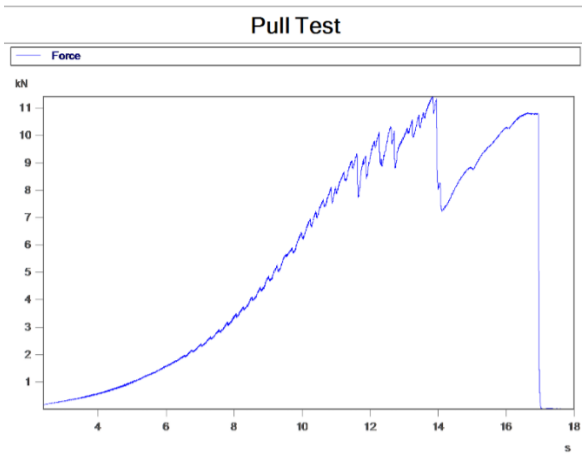
19/08/2016 09:46:45

3/8" All Line (Mexico) knotted strength test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 57:

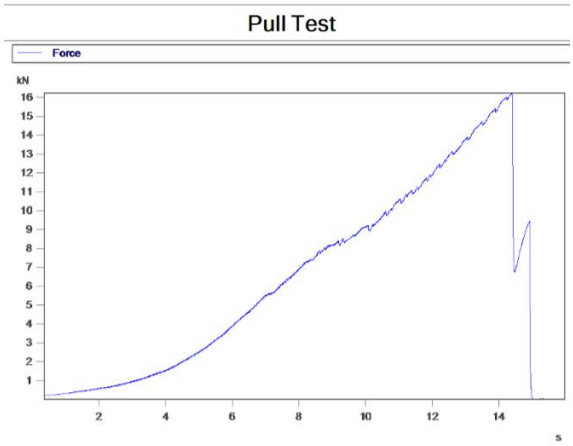


Max Force = 11.425 kN
Force Sample Rate = 500 Hz

19/08/2016 09:50:11

3/8" All Line (Mexico) knotted strength test

Test 58:

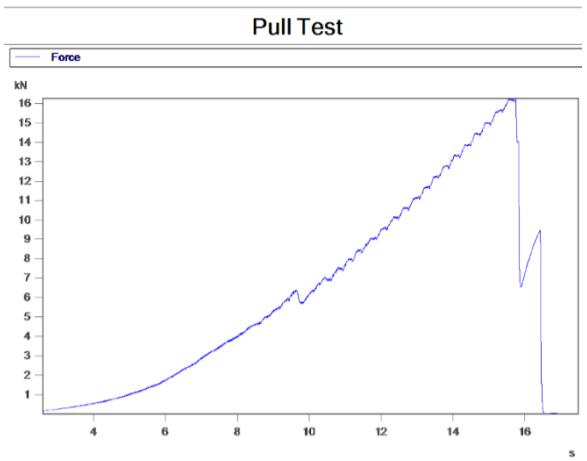


Max Force = 16.233 kN
Force Sample Rate = 500 Hz

19/08/2016 09:56:07

Bluewater R3 1-2 knotted strength test

Test 59:

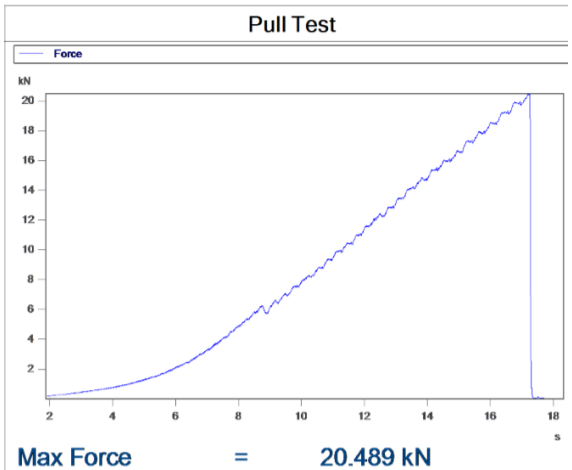


Max Force = 16.265 kN
Force Sample Rate = 500 Hz

19/08/2016 09:59:48

Bluewater R3 1-2 knotted strength test

Test 60:



Max Force = 20.489 kN
Force Sample Rate = 500 Hz

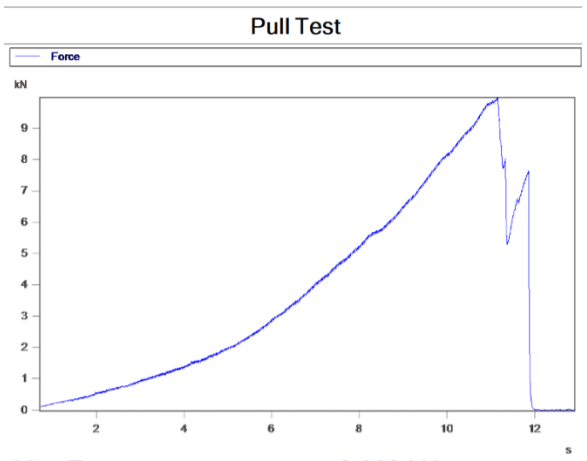
19/08/2016 10:03:24

Bluewater R3 1-2 knotted strength test

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

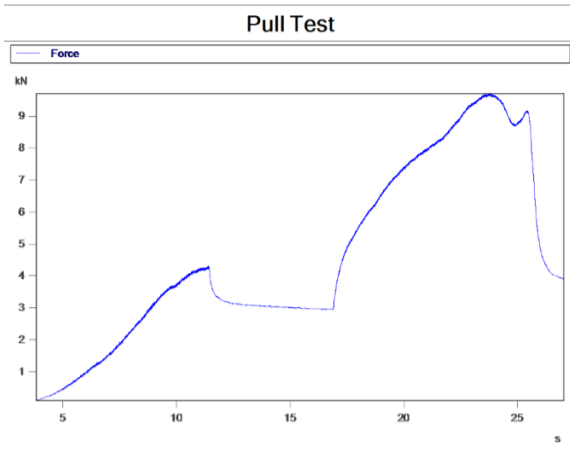
Test 61:



Max Force = 9.983 kN
Force Sample Rate = 500 Hz

19/08/2016 11:44:51
BW 7/16" HR3 with 3W 5mm Titan Prusik

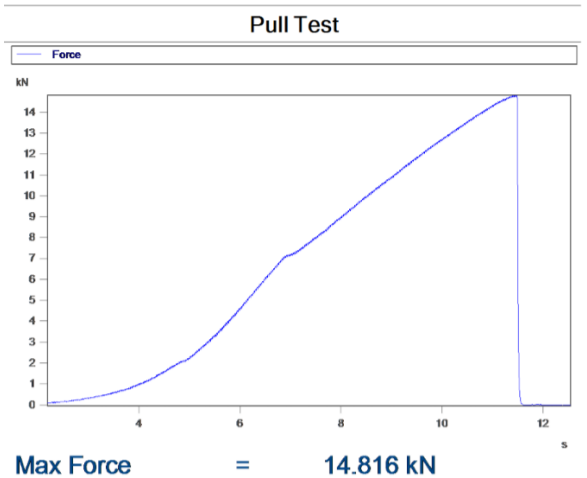
Test 62:



Max Force = 9.707 kN
Force Sample Rate = 500 Hz

19/08/2016 13:02:23
BW 7/16" HR3 with 3W 5mm Titan Prusik

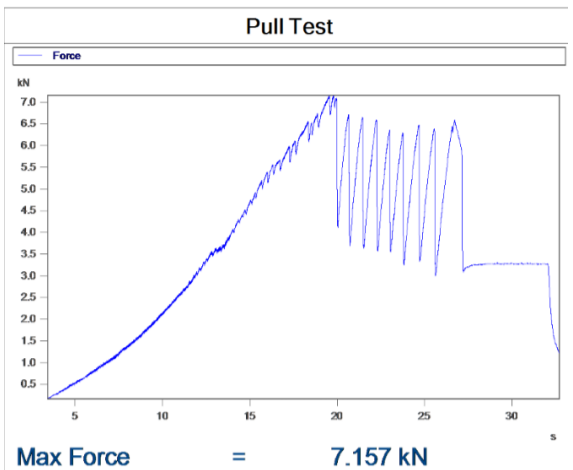
Test 63:



Max Force = 14.816 kN
Force Sample Rate = 500 Hz

19/08/2016 13:05:28
BW 7/16" HR3 with 3W 5mm Titan Prusik

Test 64:



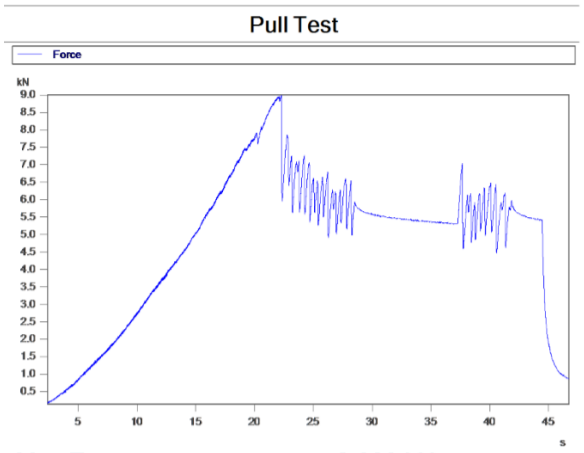
Max Force = 7.157 kN
Force Sample Rate = 500 Hz

19/08/2016 13:10:50
BW 7/16" HR3 with 3W 6mm CMC Prusik

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 65:

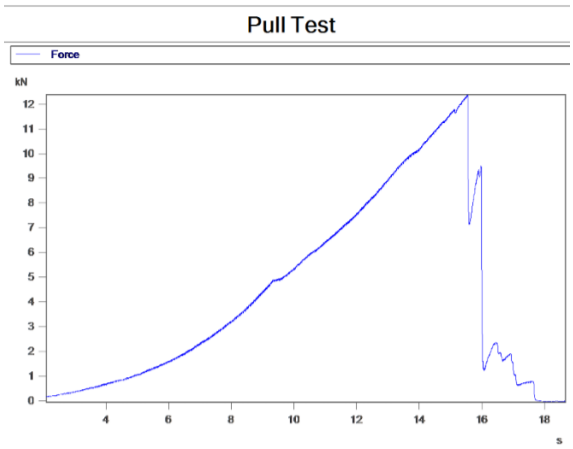


Max Force = 9.000 kN
Force Sample Rate = 500 Hz

19/08/2016 13:16:43

BW 7/16" HR3 with 3W 7mm CMC Prusik

Test 66:

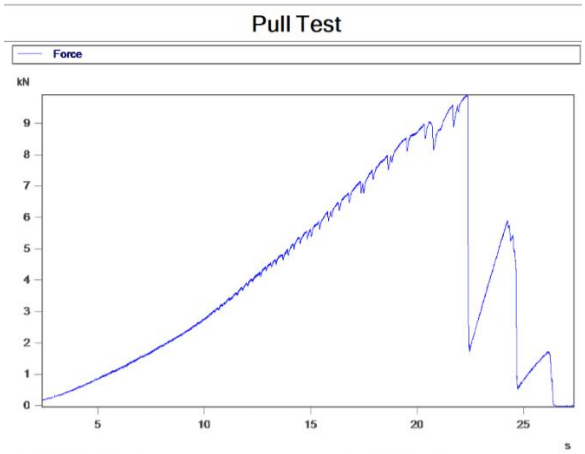


Max Force = 12.386 kN
Force Sample Rate = 500 Hz

19/08/2016 13:25:46

BW 3/8 R3 with 3W 5mm Titan Prusik

Test 67:

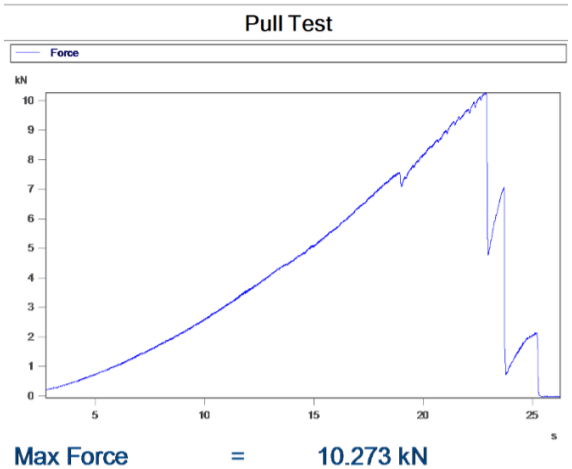


Max Force = 9.911 kN
Force Sample Rate = 500 Hz

19/08/2016 13:29:48

BW 3/8 R3 with 3W 6mm CMC Prusik

Test 68:



Max Force = 10.273 kN
Force Sample Rate = 500 Hz

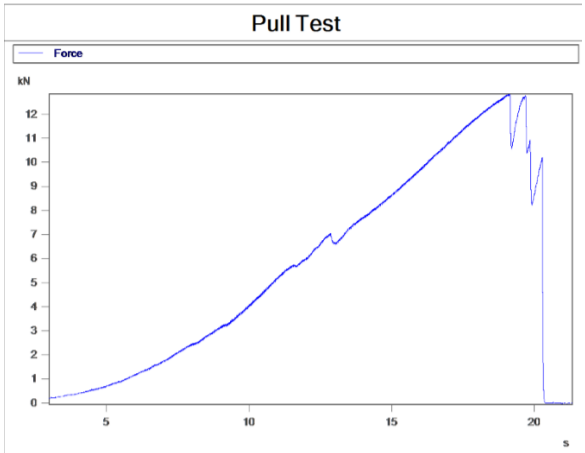
19/08/2016 13:33:37

BW 3/8 R3 with 3W 6mm CMC Prusik

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 69:

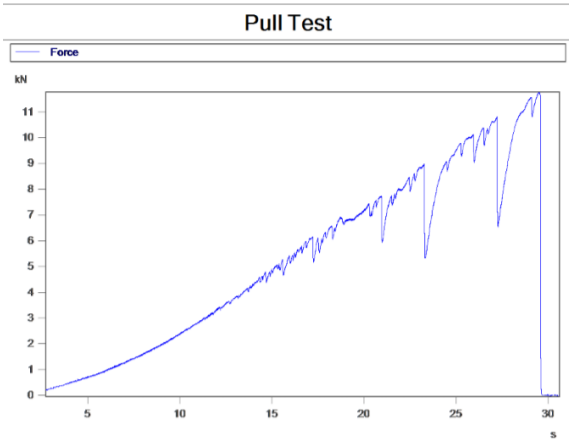


Max Force = 12.843 kN
Force Sample Rate = 500 Hz

19/08/2016 13:38:54

PMI 10mm with 3W 5mm Titan Prusik

Test 70:

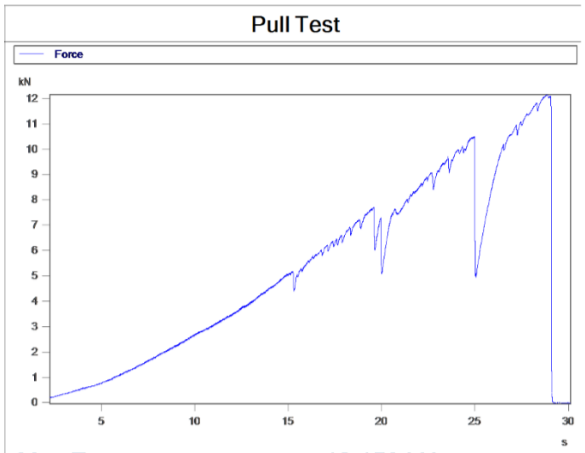


Max Force = 11.775 kN
Force Sample Rate = 500 Hz

19/08/2016 13:42:52

PMI 10mm with 3W 6mm CMC Prusik

Test 71:

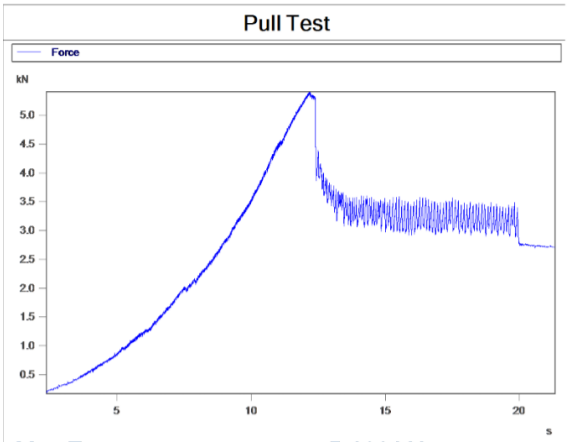


Max Force = 12.150 kN
Force Sample Rate = 500 Hz

19/08/2016 13:47:46

PMI 10mm with 3W 7mm CMC Prusik

Test 72:



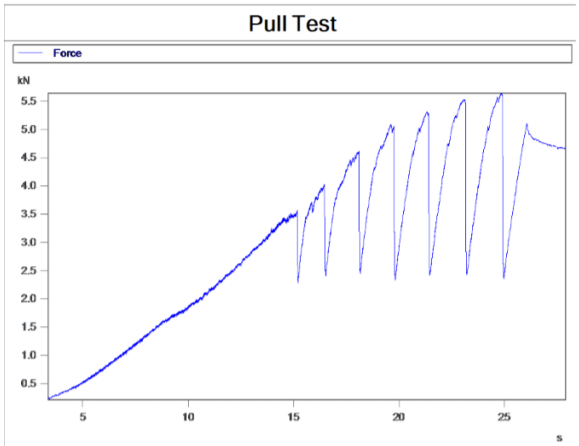
Max Force = 5.411 kN
Force Sample Rate = 500 Hz

19/08/2016 13:52:42

Esprit 5/16 with 3W 5mm Titan Prusik

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

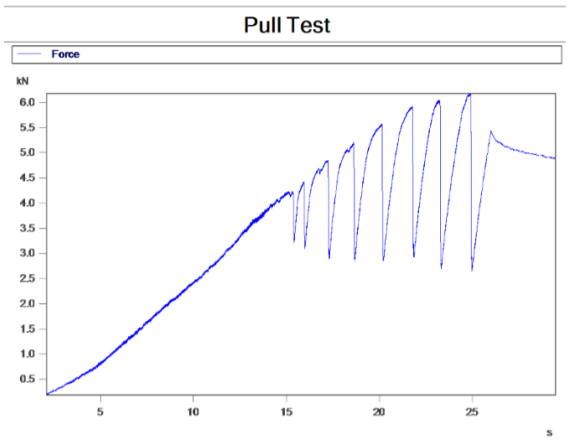
Test 73:



Max Force = 5.643 kN
Force Sample Rate = 500 Hz

19/08/2016 13:57:57
Esprit 5/16 with 3W 6mm CMC Prusik

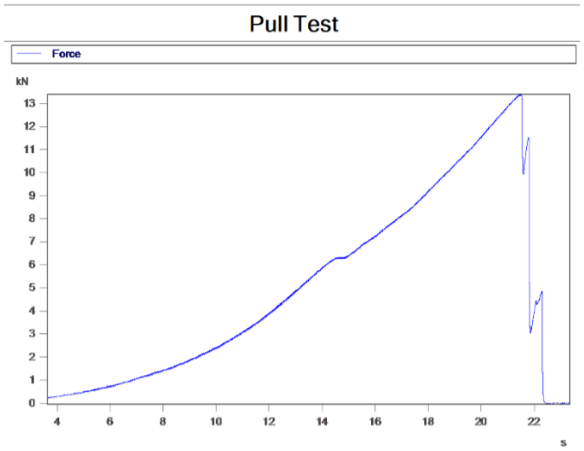
Test 74:



Max Force = 6.180 kN
Force Sample Rate = 500 Hz

19/08/2016 14:01:10
Esprit 5/16 with 3W 7mm CMC Prusik

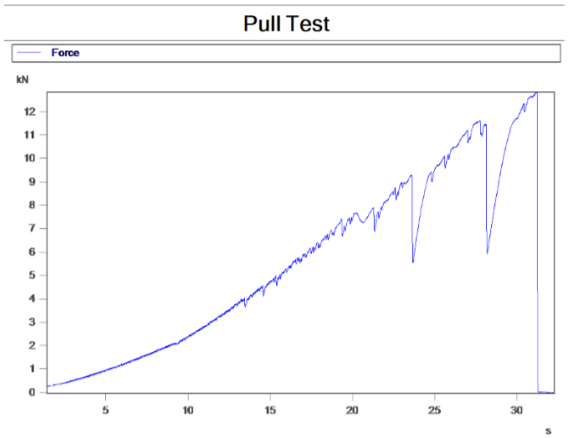
Test 75:



Max Force = 13.404 kN
Force Sample Rate = 500 Hz

19/08/2016 14:08:54
CMC 7/16" Riverline 5mm Titan Prusik

Test 76:

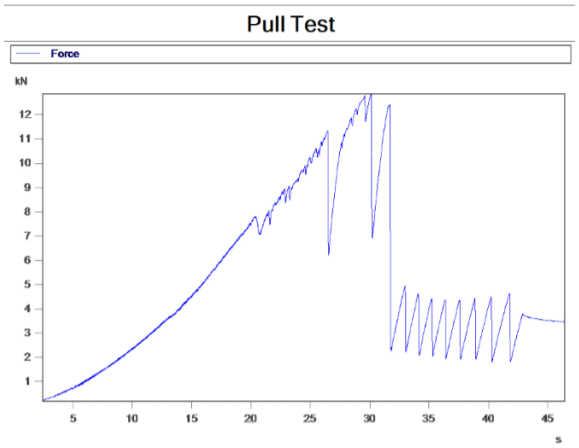


Max Force = 12.847 kN
Force Sample Rate = 500 Hz

19/08/2016 14:13:42
CMC 7/16" Riverline 6 mm CMC Prusik

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

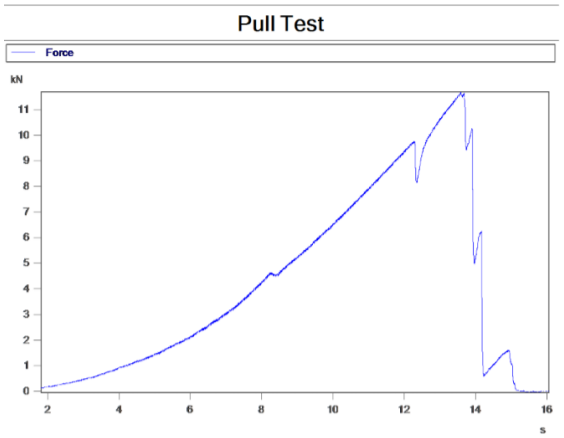
Test 77:



Max Force = 12.868 kN
Force Sample Rate = 500 Hz

19/08/2016 14:21:22
CMC 7/16" Riverline 7 mm CMC Prusik

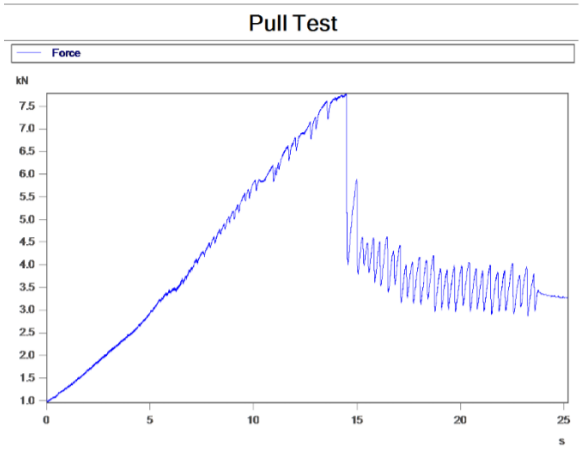
Test 78:



Max Force = 11.693 kN
Force Sample Rate = 500 Hz

19/08/2016 14:28:03
BW 7/16" Sure Grip 5 mm Titan Prusik

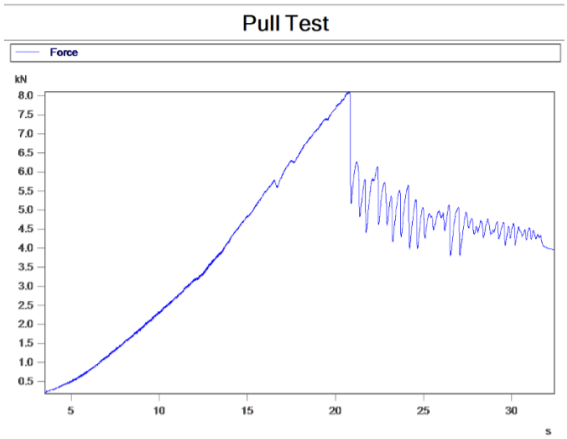
Test 79:



Max Force = 7.784 kN
Force Sample Rate = 500 Hz

19/08/2016 14:32:04
BW 7/16" Sure Grip 6 mm CMC Prusik

Test 80:



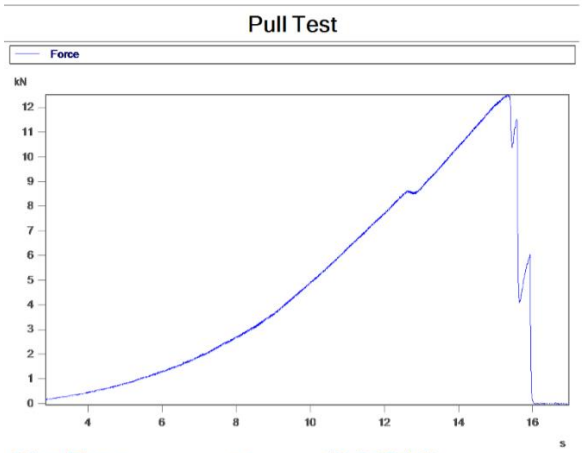
Max Force = 8.106 kN
Force Sample Rate = 500 Hz

19/08/2016 14:36:57
BW 7/16" Sure Grip 7 mm CMC Prusik

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 81:

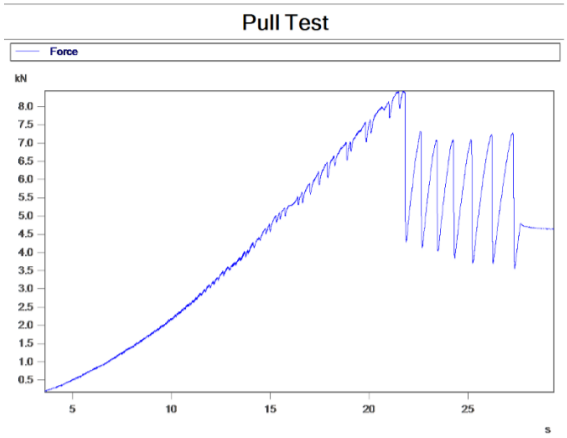


Max Force = 12.517 kN
Force Sample Rate = 500 Hz

19/08/2016 14:43:56

Sterling 1/2" Waterline 5mm Titan Prusik

Test 82:

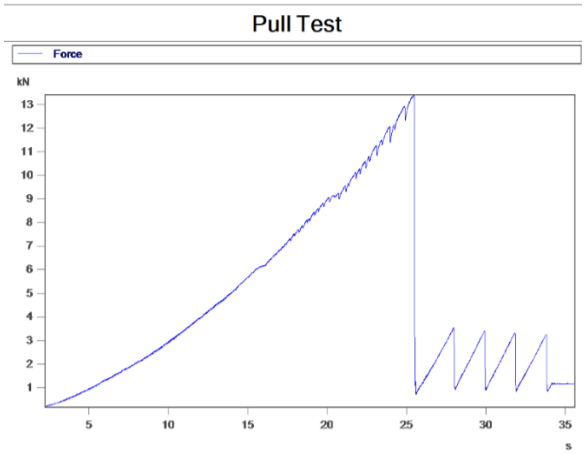


Max Force = 8.430 kN
Force Sample Rate = 500 Hz

19/08/2016 14:47:57

Sterling 1/2" Waterline 6mm CMC Prusik

Test 83:

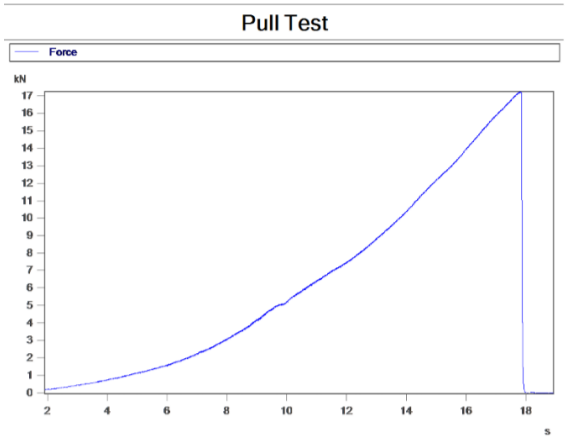


Max Force = 13.416 kN
Force Sample Rate = 500 Hz

19/08/2016 14:52:08

Sterling 1/2" Waterline 7mm CMC Prusik

Test 84:



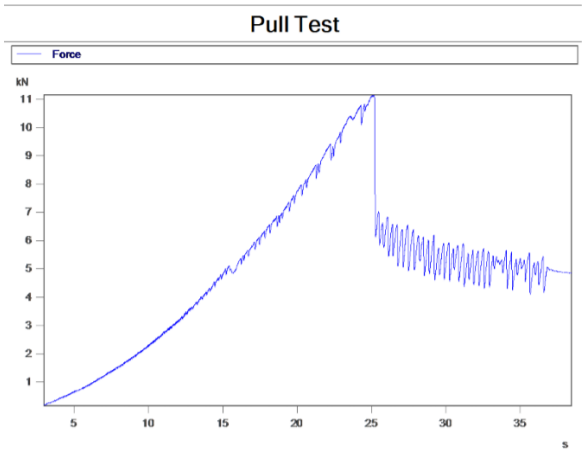
Max Force = 17.249 kN
Force Sample Rate = 500 Hz

19/08/2016 15:15:11

Bluewater HR3 1/2" 5mm Titan Prusik

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

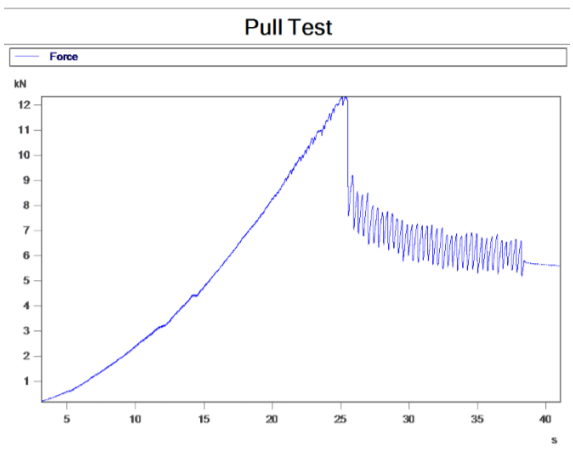
Test 85:



Max Force = 11.156 kN
Force Sample Rate = 500 Hz

19/08/2016 15:20:31
Bluewater HR3 1/2" 6mm CMC Prusik

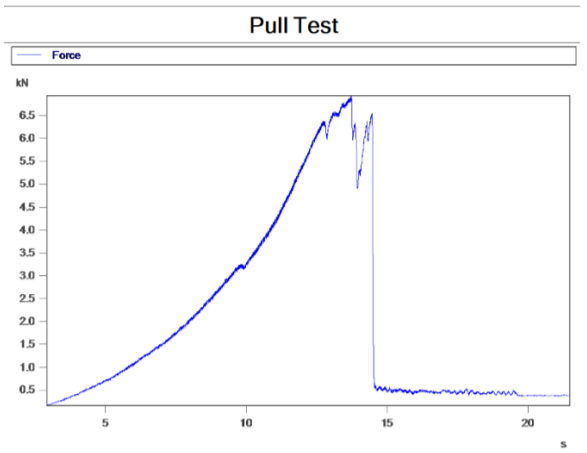
Test 86:



Max Force = 12.338 kN
Force Sample Rate = 500 Hz

19/08/2016 15:25:16
Bluewater HR3 1/2" 7mm CMC Prusik

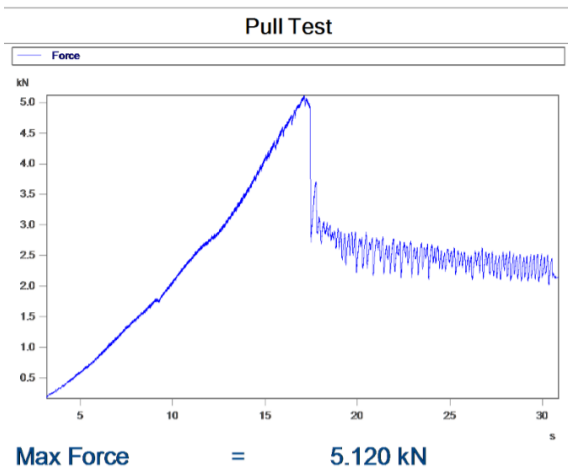
Test 87:



Max Force = 6.934 kN
Force Sample Rate = 500 Hz

19/08/2016 15:35:08
All line 3/8" (Mexico) 5mm Titan

Test 88:



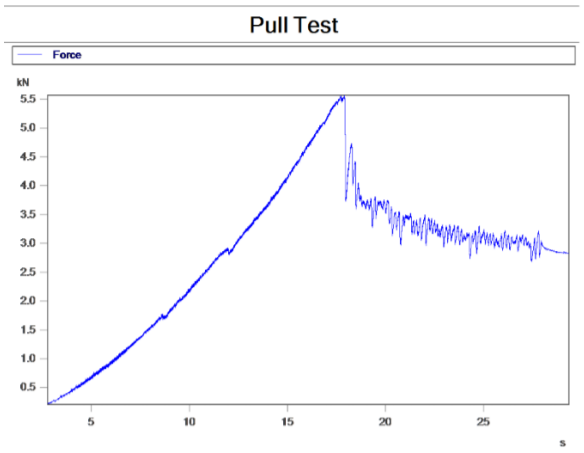
Max Force = 5.120 kN
Force Sample Rate = 500 Hz

19/08/2016 15:39:24
All line 3/8" (Mexico) 6mm CMC

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 89:

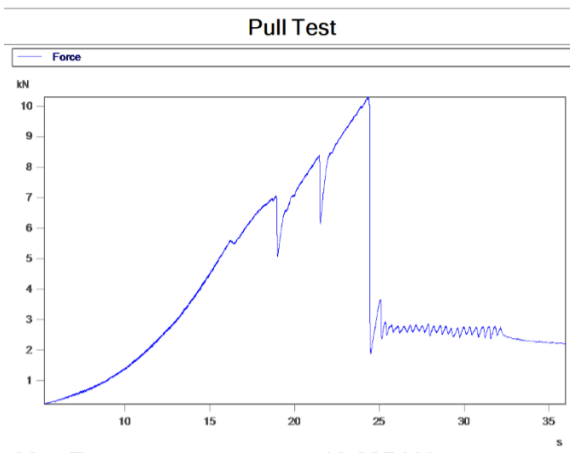


Max Force = 5.568 kN
Force Sample Rate = 500 Hz

19/08/2016 15:43:09

All line 3/8" (Mexico) 7mm CMC

Test 90:

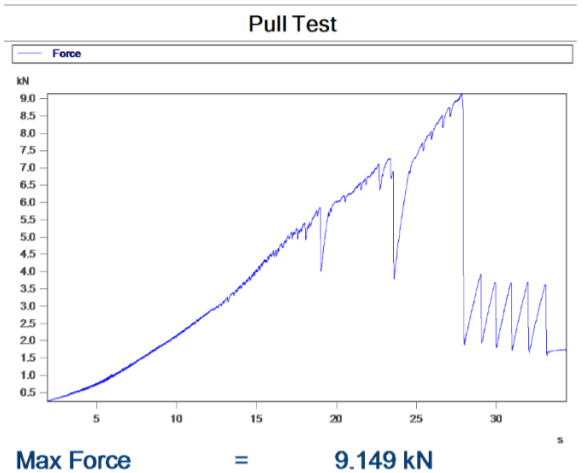


Max Force = 10.295 kN
Force Sample Rate = 500 Hz

19/08/2016 15:51:23

Bluewater R3 1/2" 5 mm Titan CMC

Test 91:

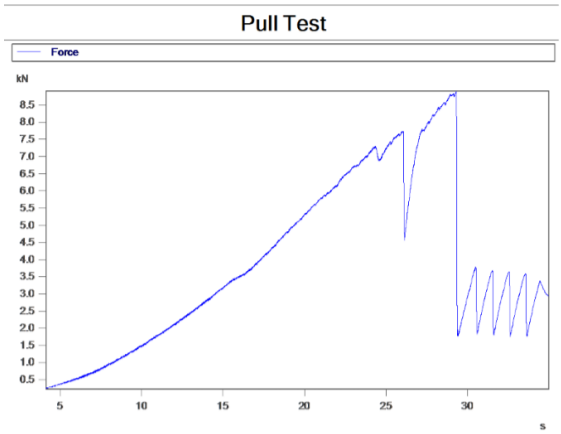


Max Force = 9.149 kN
Force Sample Rate = 500 Hz

19/08/2016 15:55:58

Bluewater R3 1/2" 6mm CMC

Test 92:



Max Force = 8.909 kN
Force Sample Rate = 500 Hz

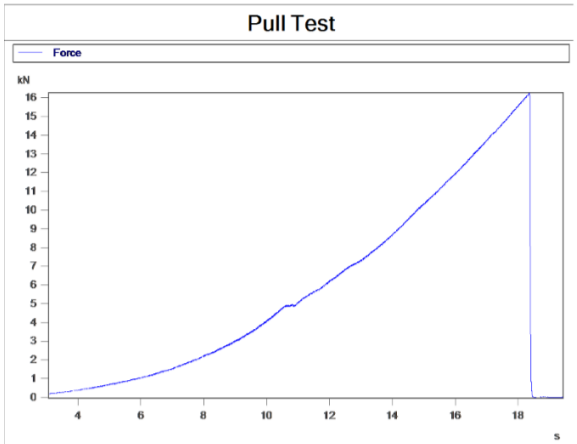
19/08/2016 15:59:55

Bluewater R3 1/2" 7mm CMC

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

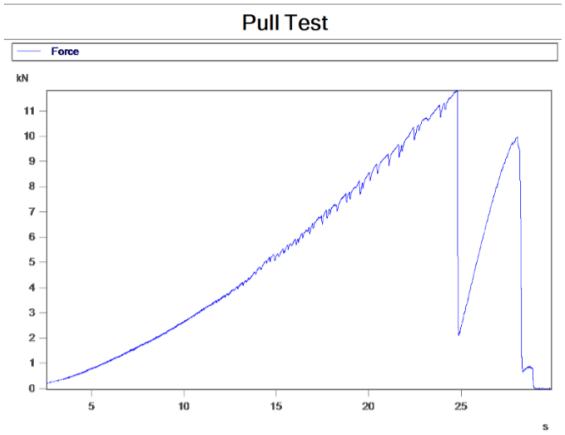
Test 93:



Max Force = 16.273 kN
Force Sample Rate = 500 Hz

19/08/2016 16:31:20
Bluewater R3 1/2" 5mm Titan

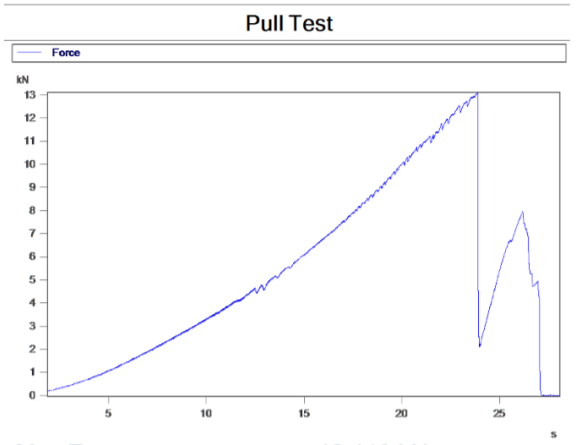
Test 94:



Max Force = 11.817 kN
Force Sample Rate = 500 Hz

19/08/2016 16:35:14
Bluewater R3 1/2" 6mm CMC

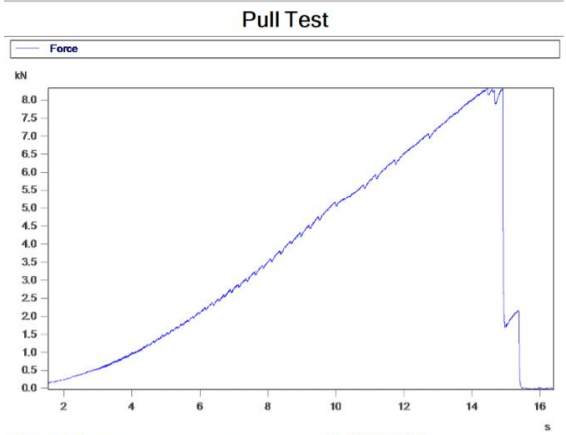
Test 95:



Max Force = 13.118 kN
Force Sample Rate = 500 Hz

19/08/2016 16:39:09
Bluewater R3 1/2" 7mm CMC

Test 96:



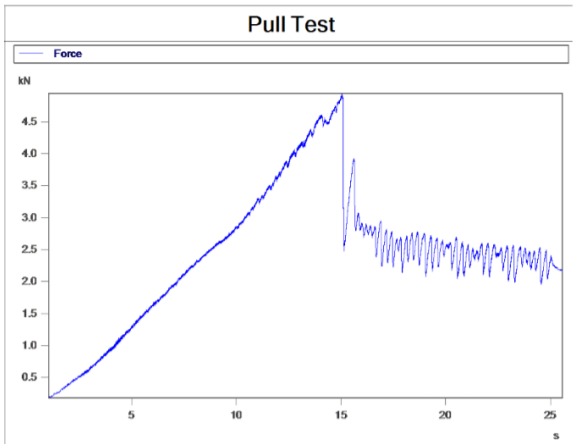
Max Force = 8.336 kN
Force Sample Rate = 500 Hz

19/08/2016 18:16:30
CMC Throwline. Redi-Line 7/16"

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 97:

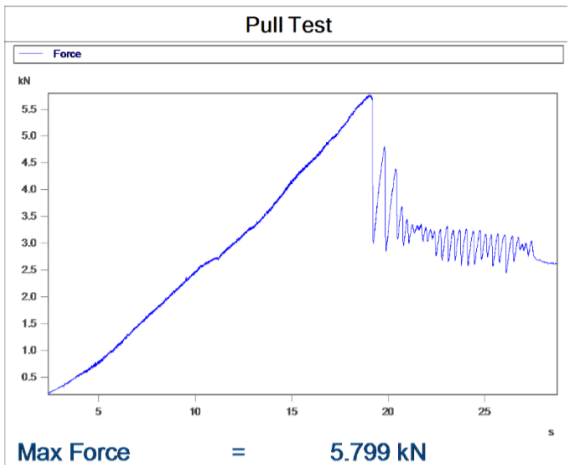


Max Force = 4.941 kN
Force Sample Rate = 500 Hz

19/08/2016 18:21:15

CMC Throwline, Redi-Line 7/16", 6mm CMC Prusik

Test 98:

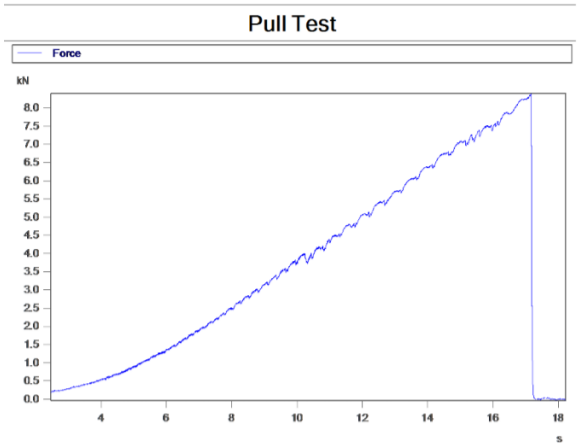


Max Force = 5.799 kN
Force Sample Rate = 500 Hz

19/08/2016 18:25:09

CMC Throwline, Redi-Line 7/16", 7mm CMC Prusik

Test 99:

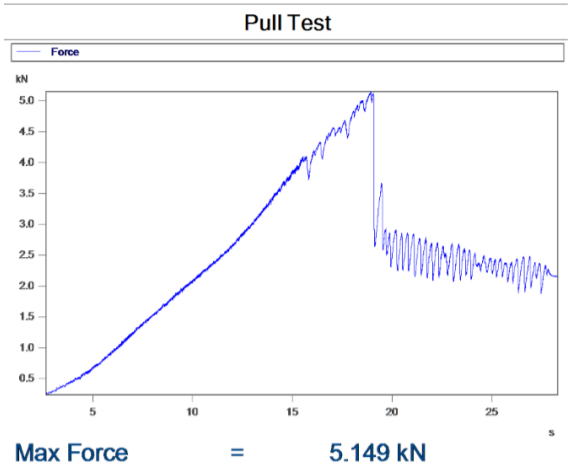


Max Force = 8.401 kN
Force Sample Rate = 500 Hz

19/08/2016 18:31:14

BW Suregrip 3/8 knotted

Test 100:



Max Force = 5.149 kN
Force Sample Rate = 500 Hz

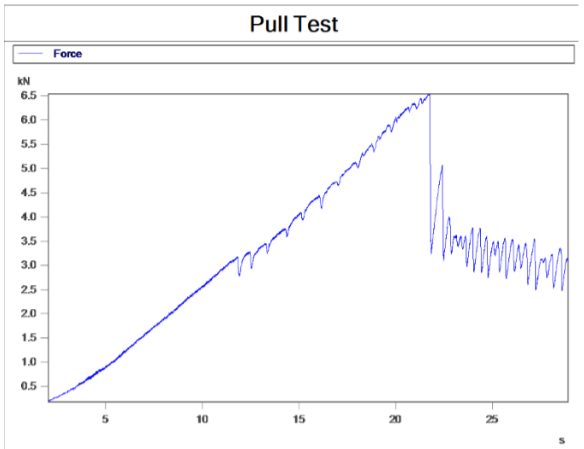
19/08/2016 18:34:46

BW Suregrip 3/8 with 6mm CMC Prusik

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 101:

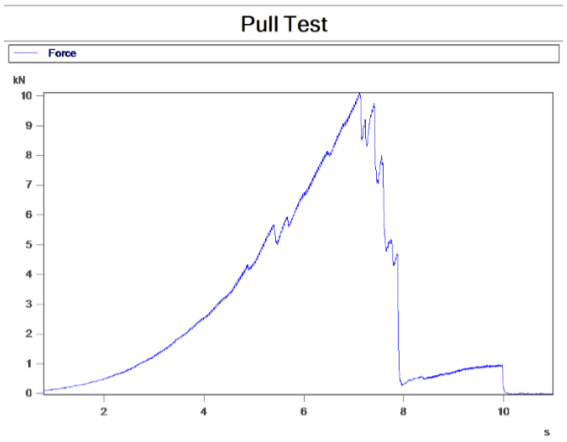


Max Force = 6.539 kN
Force Sample Rate = 500 Hz

19/08/2016 18:38:35

BW Suregrip 3/8 with 7mm CMC Prusik

Test 102:

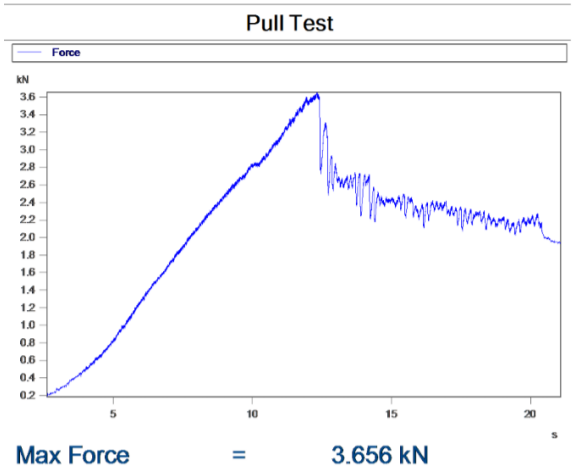


Max Force = 10.113 kN
Force Sample Rate = 500 Hz

19/08/2016 18:43:31

CMC NFPA Throwline 3/8" knotted

Test 103:

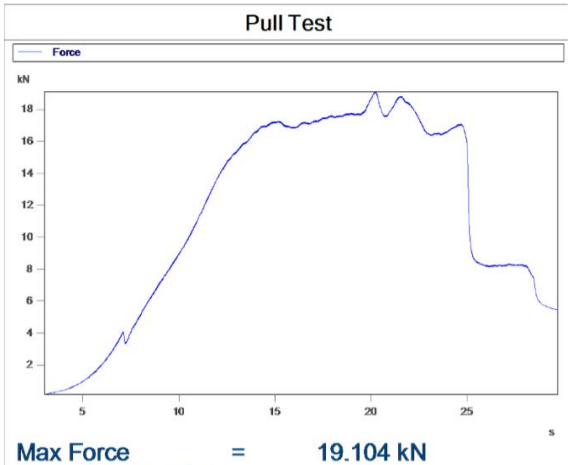


Max Force = 3.656 kN
Force Sample Rate = 500 Hz

19/08/2016 18:47:00

CMC NFPA Throwline 3/8" with CMC 6mm Prusik

Test 104:



Max Force = 19.104 kN
Force Sample Rate = 500 Hz

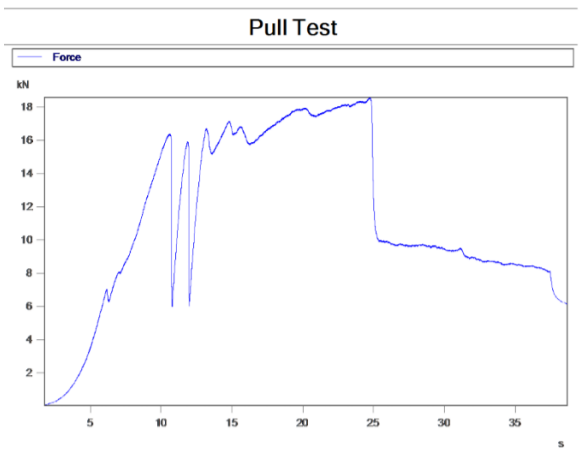
19/08/2016 18:54:25

CMC NFPA Throwline 3/8" Baseline Strength

Appendix B: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Slow Pull Test Graphs

Test 105:

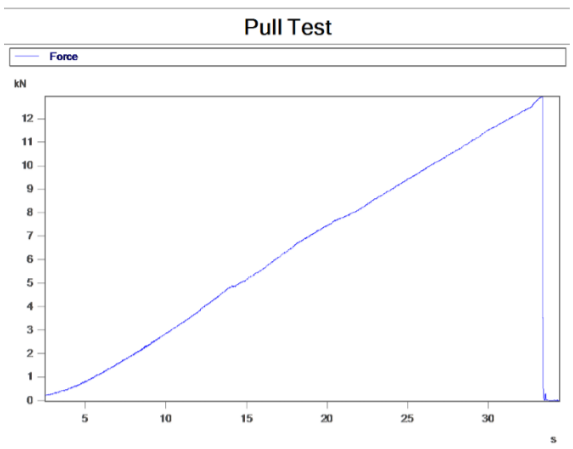


Max Force = 18.579 kN
Force Sample Rate = 500 Hz

19/08/2016 19:00:45

CMC NFPA Throwline 3/8" Baseline Strength

Test 106:

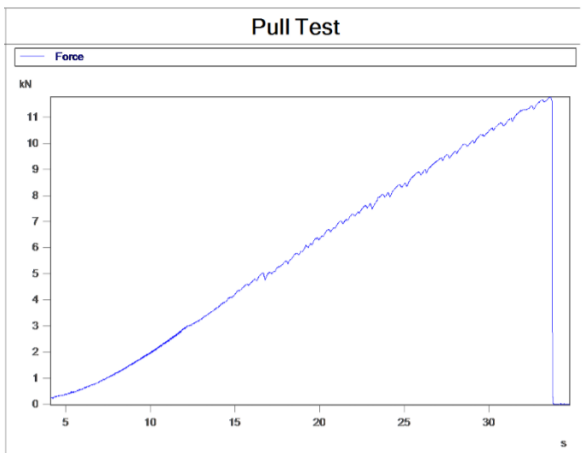


Max Force = 12.957 kN
Force Sample Rate = 500 Hz

19/08/2016 19:06:50

CMC Throwline Redi-Line 7/16" Strength Test

Test 107:



Max Force = 11.782 kN
Force Sample Rate = 500 Hz

19/08/2016 19:12:31

BW Sure Grip 3/8" Strength Test

Appendix C:

BASECAMP INNOVATIONS LTD 2016

NIF 2016 EMBC & BCSARA

Swiftwater Rescue Craft Drag Tests Summary

Watercraft:		Operator Position			
Tributary 9.5' HD		Center	Bow	Stern	
	Speed (kph)	Max Force (kN)	Max Force (kN)	Max Force (kN)	Comments/Observations:
1 Person (0.7 kN) Load:	5.0	0.04	0.08	0.09	
	7.0	0.12	0.44	0.32	
	10.0	0.30	0.45	0.70	
2 Person (1.6 kN) Load:	5.0	0.11	0.11	0.18	
	7.0	0.14	0.78	0.30	
	10.0	0.54	1.65	1.03	boat nose-dived with load in bow position

Watercraft:		Operator Position			
Oceanid RDC		Center	Bow	Stern	
	Speed (kph)	Max Force (kN)	Max Force (kN)	Max Force (kN)	Comments/Observations:
1 Person (0.7 kN) Load:	5.0	0.05	0.13	0.05	
	7.0	0.24	0.27	0.11	
	10.0	0.52	0.88	0.20	
2 Person (1.6 kN) Load:	5.0	0.08	0.13	0.06	
	7.0	0.33	0.52	0.12	
	10.0	0.33	1.64	0.42	bow area flooded

Watercraft:		Operator Position			
AIRE 143 E-Series		Center	Bow	Stern	
	Speed (kph)	Max Force (kN)	Max Force (kN)	Max Force (kN)	Comments/Observations:
1 Person (0.7 kN) Load:	5.0	0.02	0.05	0.05	
	7.0	0.05	0.11	0.08	
	10.0	0.29	0.37	0.42	
2 Person (1.6 kN) Load:	5.0	0.02	0.04	0.03	
	7.0	0.08	0.17	0.17	
	10.0	0.40	0.65	0.76	
3 Person Load:	5.0	0.05	0.07	0.08	
	7.0	0.12	0.21	0.23	
	10.0	0.31	0.63	0.99	

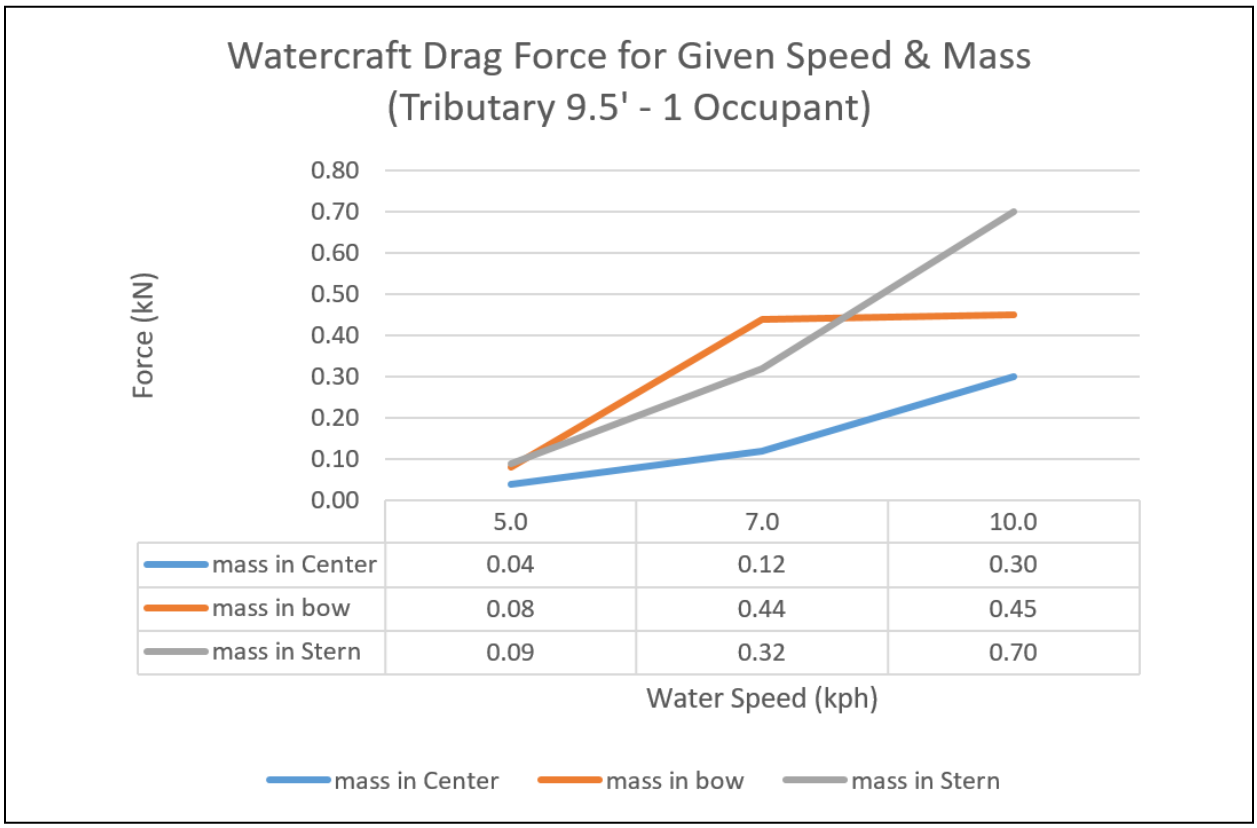
Watercraft:		Operator Position			
NRS Otter 140		Center	Bow	Stern	
	Speed (kph)	Max Force (kN)	Max Force (kN)	Max Force (kN)	Comments/Observations:
2 Person (1.6 kN) Load:	5.0	0.06	0.12	0.14	
	7.0	0.11	0.21	0.35	
	10.0	0.35	0.59	1.24	

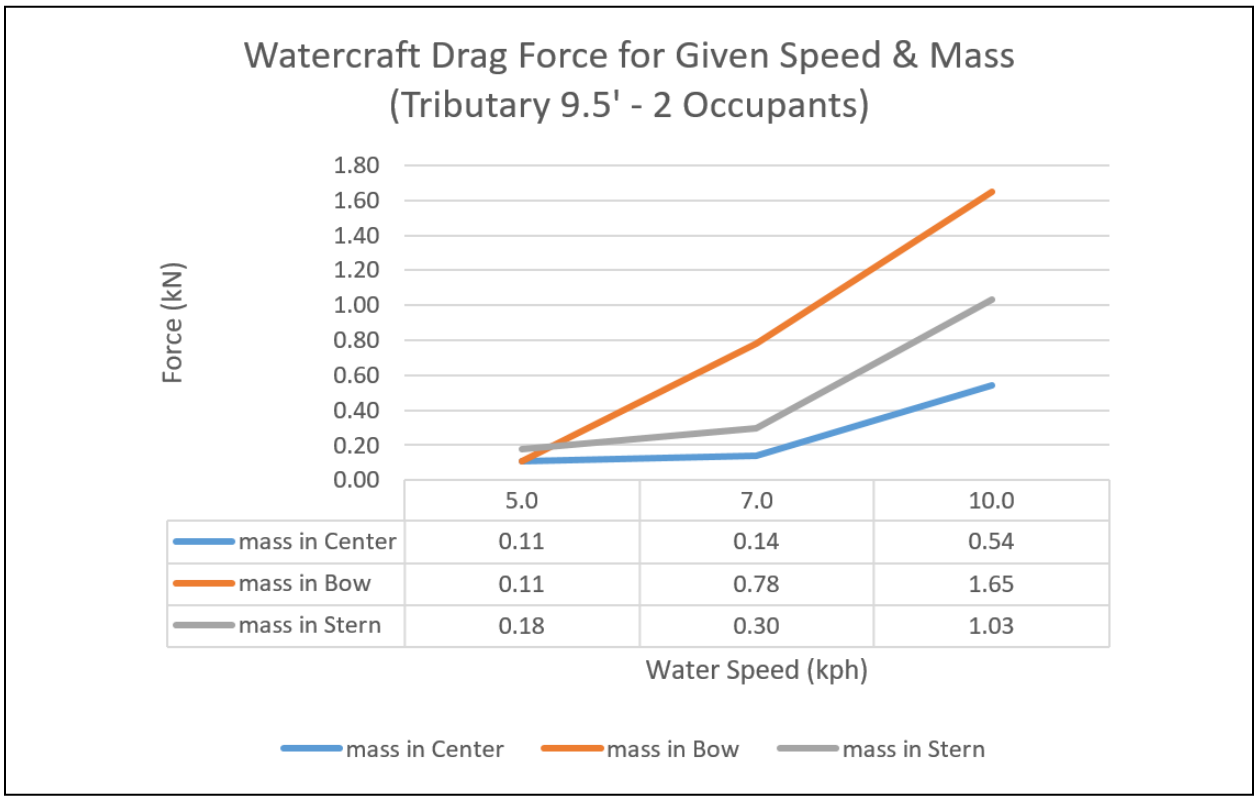
Watercraft:	Centre Position		Oar Drag	
Hyside Cataraft 14'	Speed (kph)	Max Force (kN)	Max Force (kN)	Comments/Observations:
1 Person (0.7 kN) Load:	5.0	0.05	0.13	no bow or stern position with this watercraft
	7.0	0.07	0.39	"
	10.0	0.23	0.39	"
2 Person (1.6 kN) Load:	7.0	0.13	0	
	10.0	0.35	0	

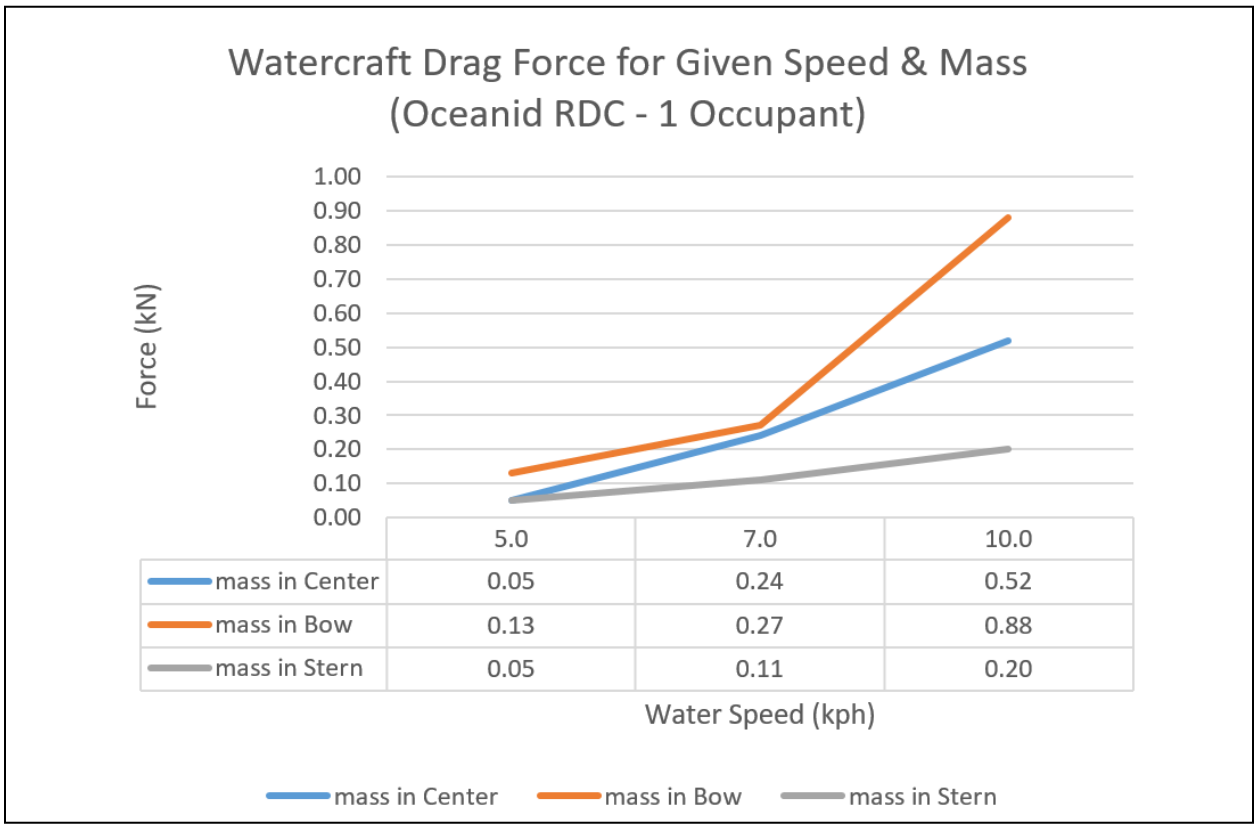
Watercraft:	Centre Position		
AIRE Ocelot 14'	Speed (kph)	Max Force (kN)	Comments/Observations:
1 Person (0.7 kN) Load:	5.0	0.04	
	7.0	0.10	
	10.0	0.20	
2 Person (1.6 kN) Load:	5.0	0.08	people positioned centre and also rear
	7.0	0.13	"
	10.0	0.36	"

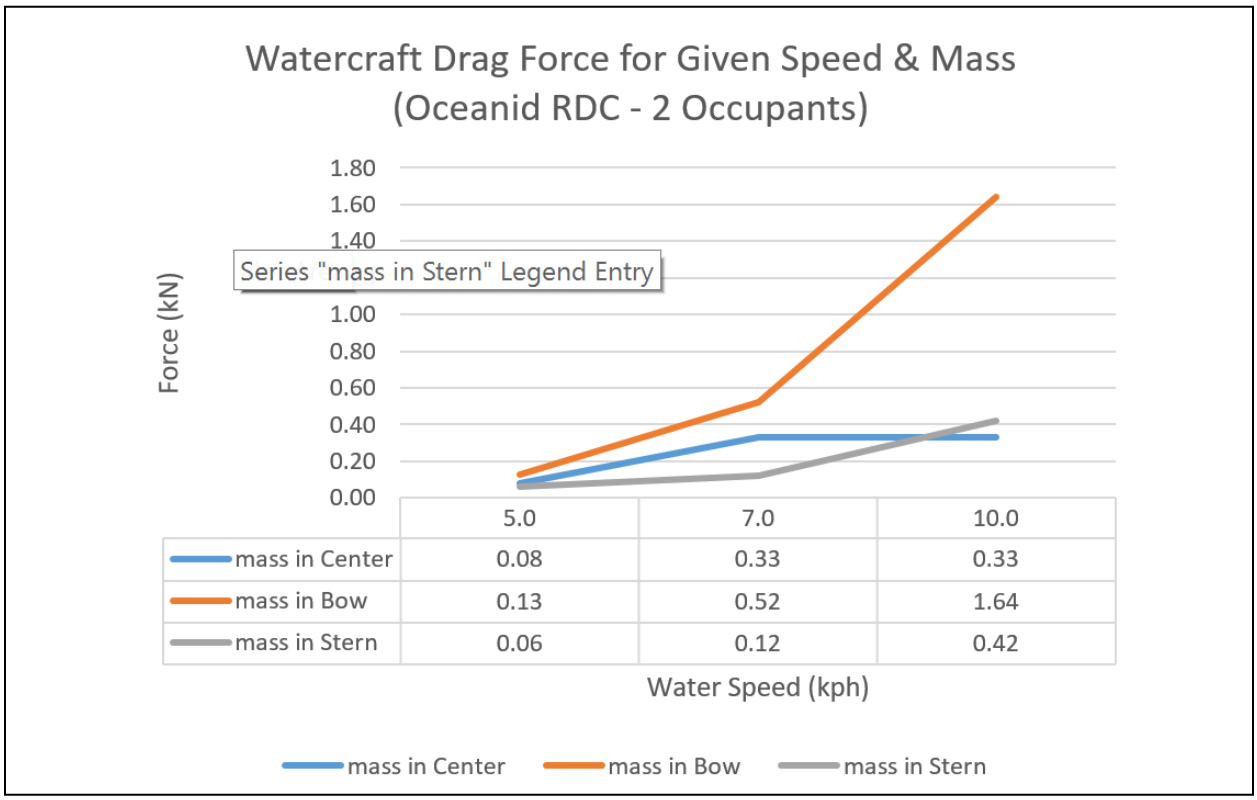
Dorsal Attachment Drag:	speed	mass of Swiftwater Technician			
* one person	(kph)	(~70 kg)	(~90 kg)	(~150 kg)	Comments/Observations:
* feet not on ground	5.0	0.29	0.35	0.55	
	7.0	0.44	0.54	0.83	
	10.0	0.58	0.74	1.31	pressure around chest cavity very noticable

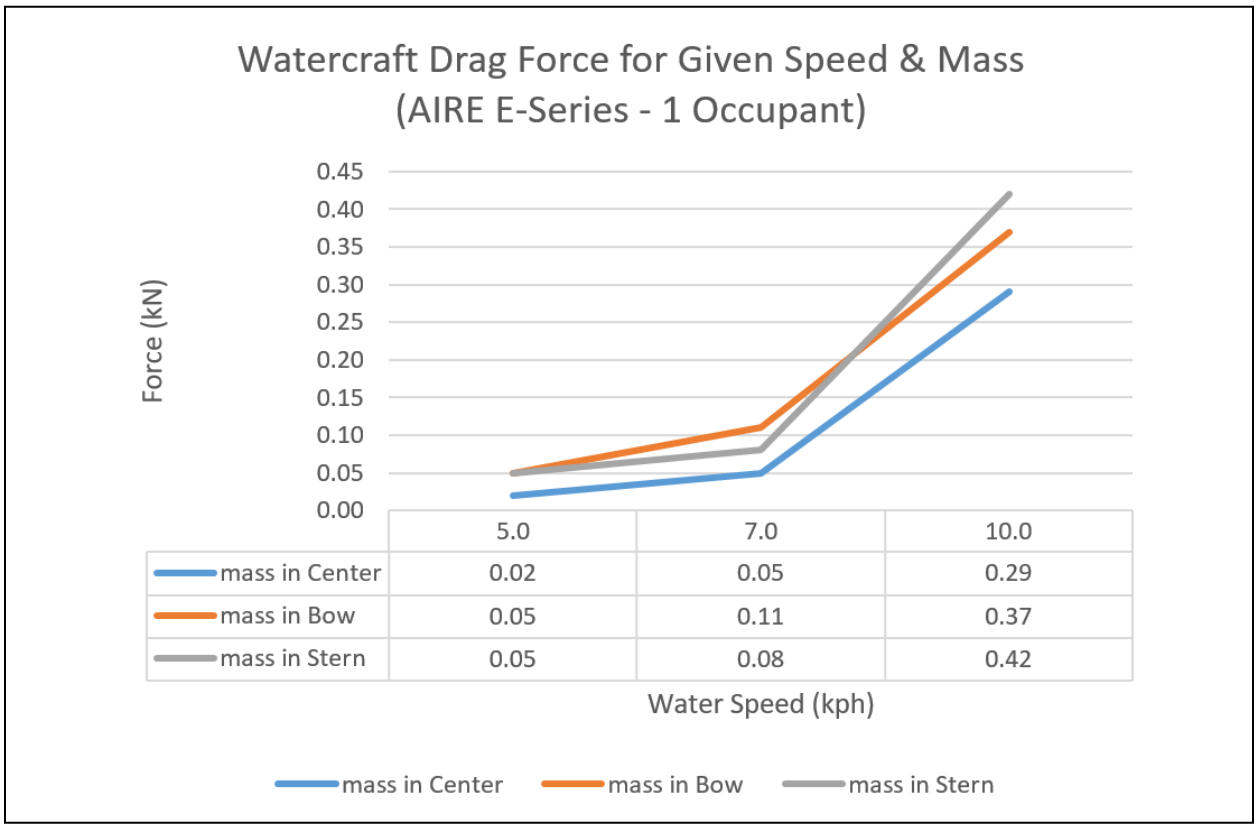
Note: Speed varied +/- 0.4 kph

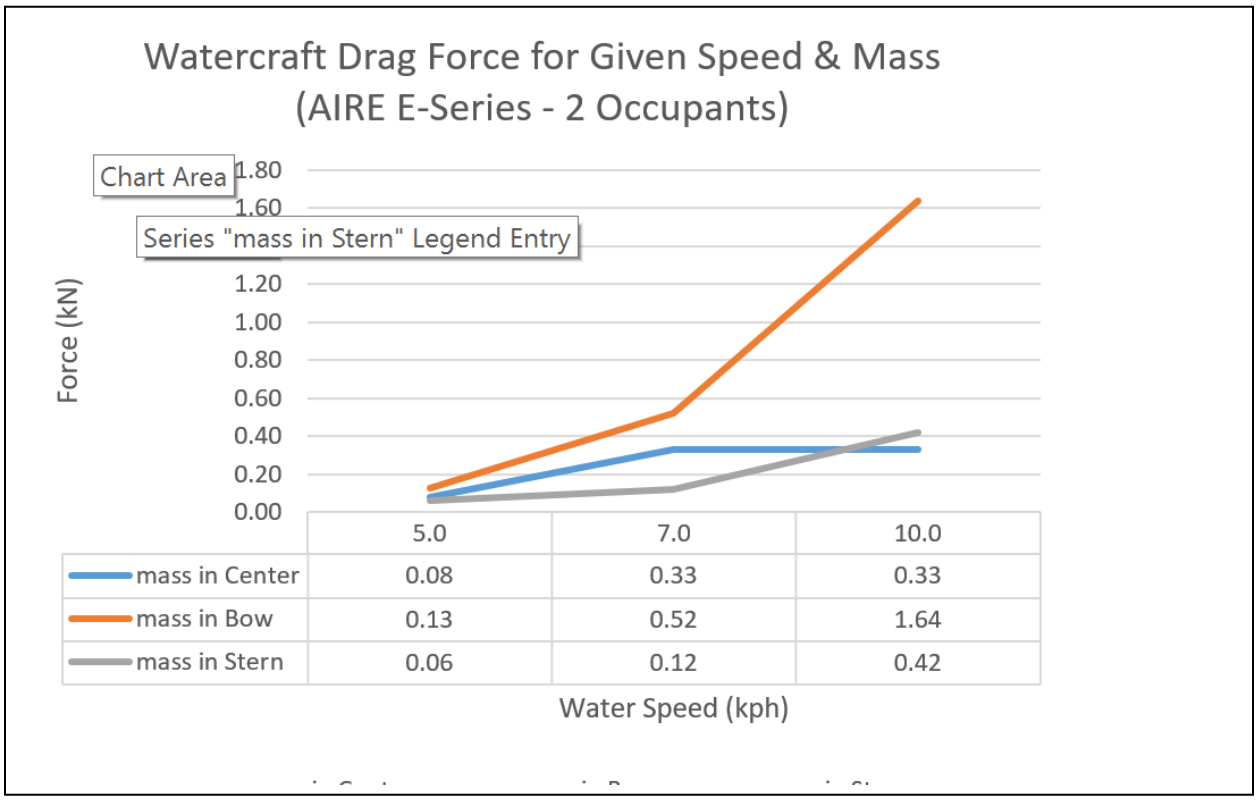

Watercraft Drag Force for Given Speed & Mass
(Tributary 9.5' - 1 Occupant)
Force (kN)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
5.0
7.0
10.0
mass in Center 0.04 0.12 0.30
mass in bow 0.08 0.44 0.45
mass in Stern 0.09 0.32 0.70
Water Speed (kph)
mass in Center
mass in bow
mass in Stern

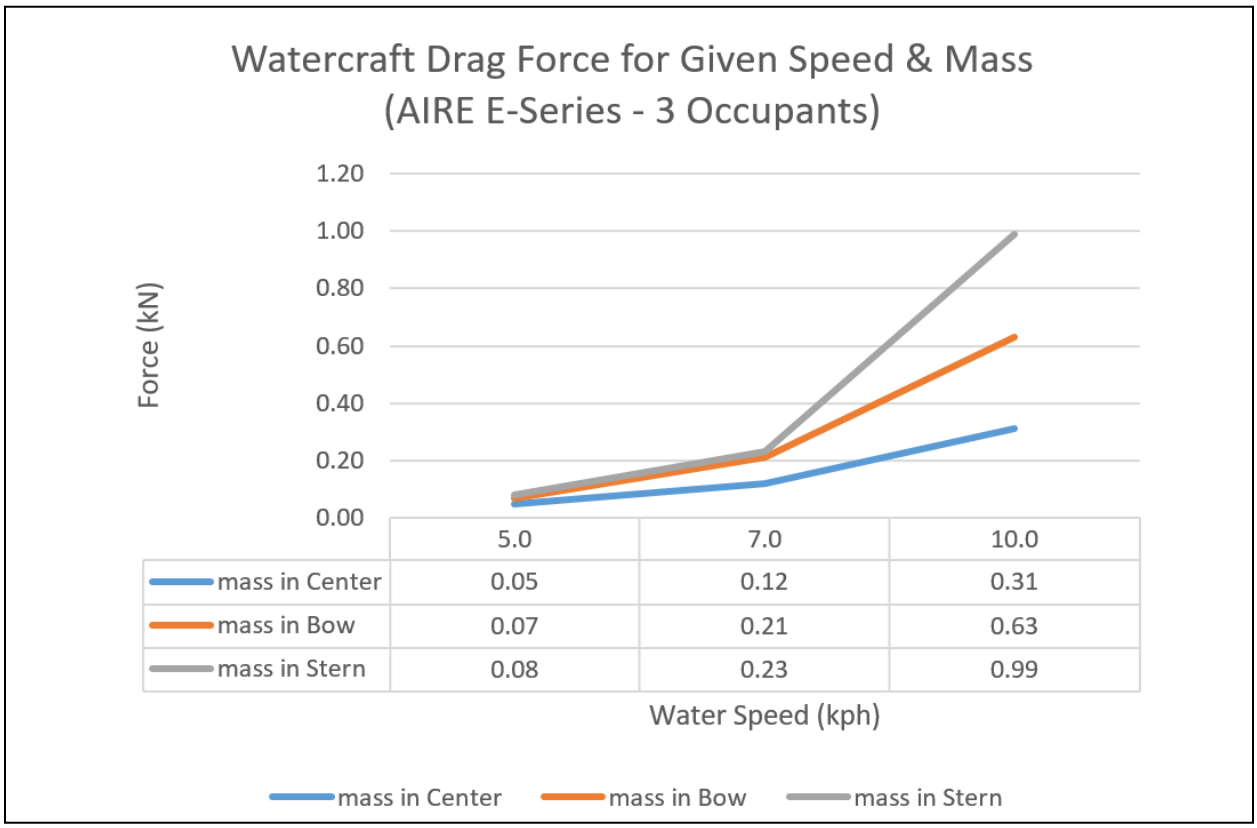

Watercraft Drag Force for Given Speed & Mass
(Tributary 9.5' - 2 Occupants)
Force (kN)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
5.0
7.0
10.0
mass in Center 0.11 0.14 0.54
mass in Bow 0.11 0.78 1.65
mass in Stern 0.18 0.30 1.03
Water Speed (kph)
mass in Center
mass in Bow
mass in Stern

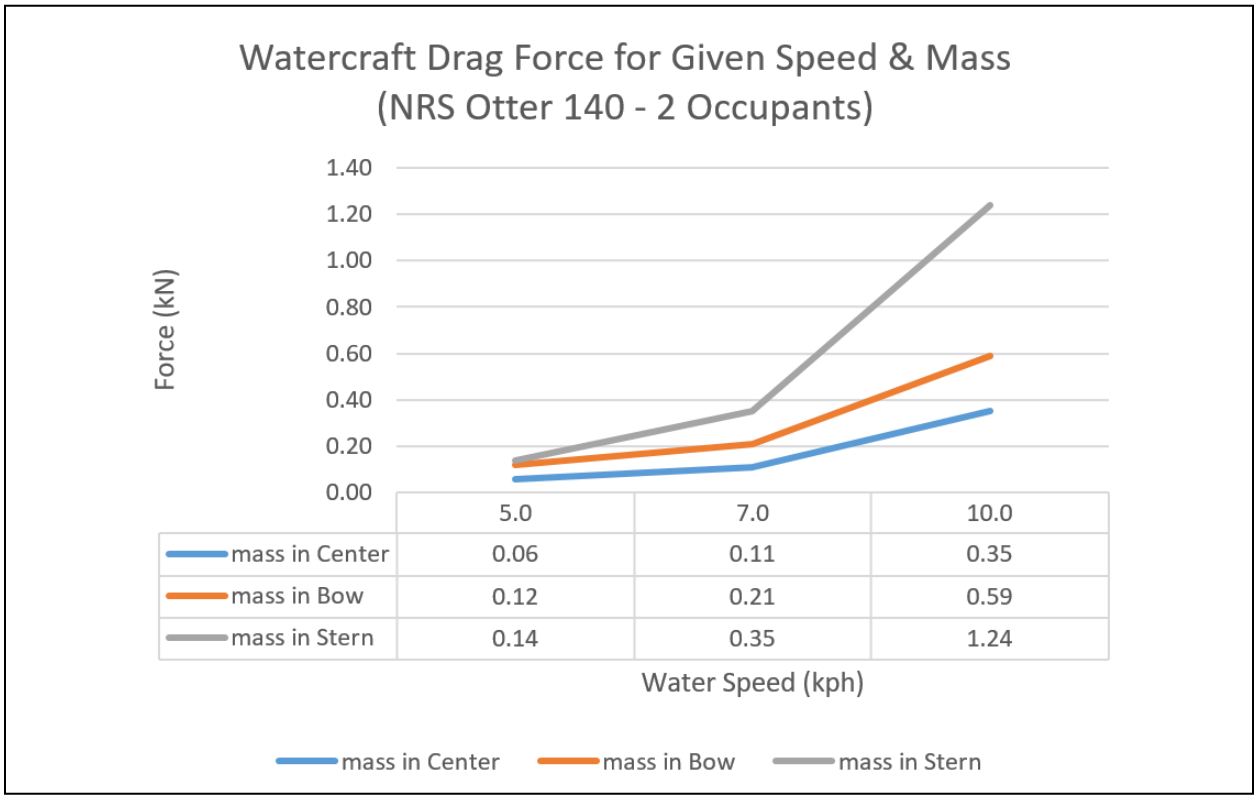

Watercraft Drag Force for Given Speed & Mass
(Oceanid RDC - 1 Occupant)
Force (kN)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
5.0
7.0
10.0
mass in Center
0.05
0.24
0.52
mass in Bow
0.13
0.27
0.88
mass in Stern
0.05
0.11
0.20
Water Speed (kph)
mass in Center
mass in Bow
mass in Stern

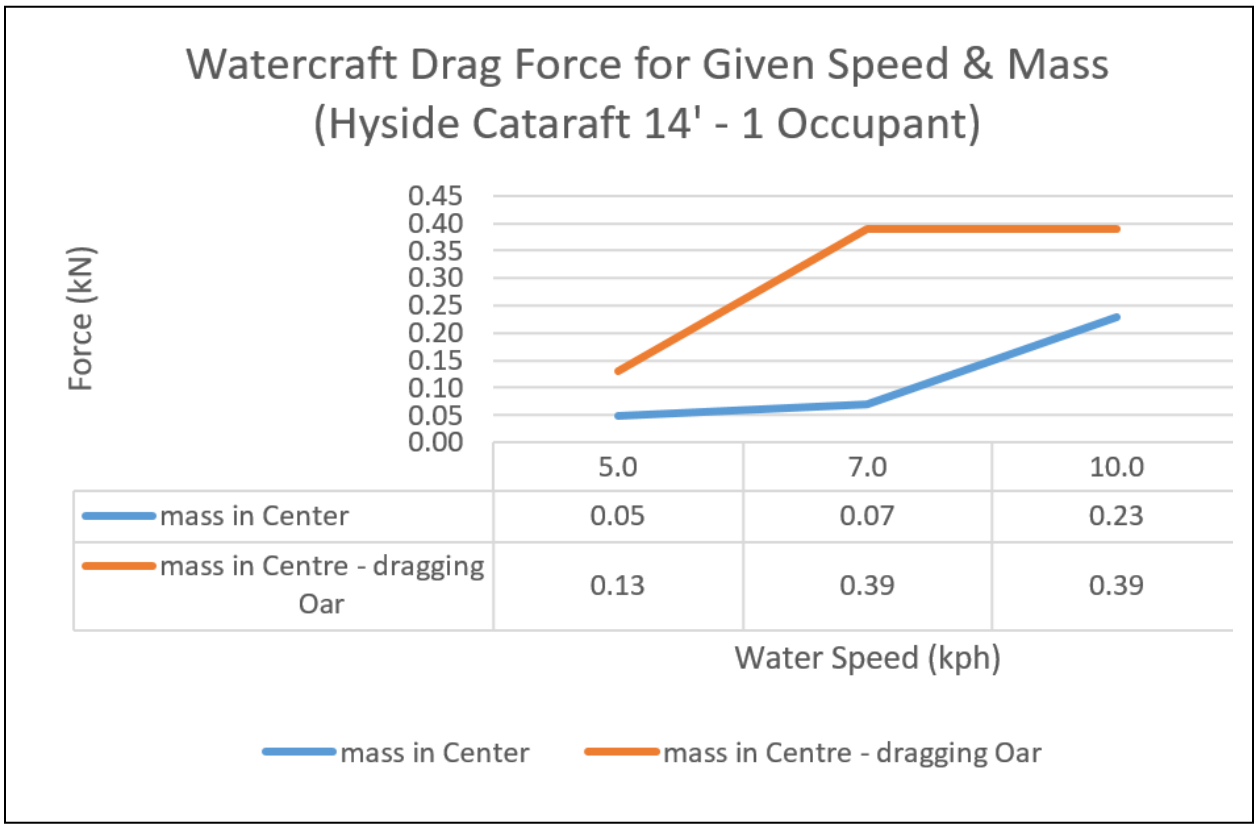

Watercraft Drag Force for Given Speed & Mass
(Oceanid RDC - 2 Occupants)
Force (kN)
1.80
1.60
1.40
Series "mass in Stern" Legend Entry
1.00
0.80
0.60
0.40
0.20
0.00
5.0
7.0
10.0
mass in Center
0.08
0.33
0.33
mass in Bow
0.13
0.52
1.64
mass in Stern
0.06
0.12
0.42
Water Speed (kph)
mass in Center
mass in Bow
mass in Stern

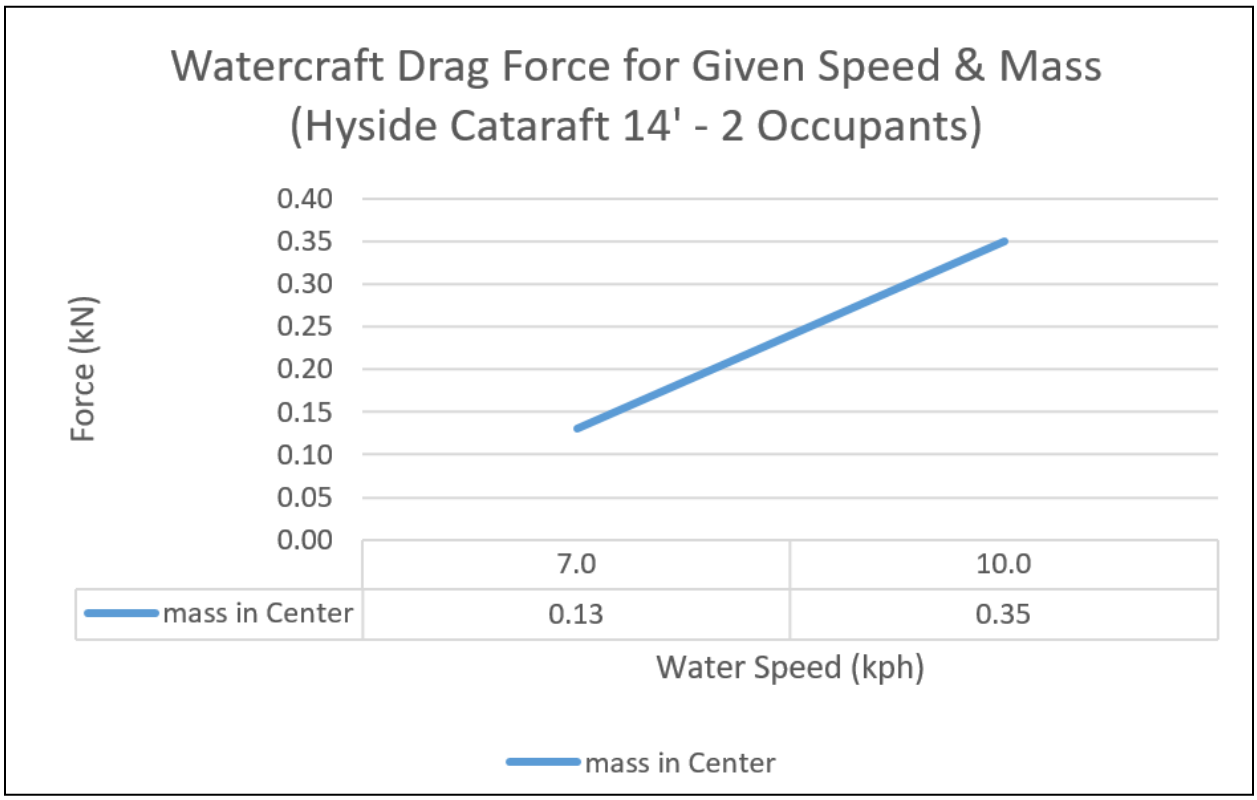

Watercraft Drag Force for Given Speed & Mass
(AIRE E-Series - 1 Occupant)
Force (kN)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5.0
7.0
10.0
mass in Center
0.02
0.05
0.29
mass in Bow
0.05
0.11
0.37
mass in Stern
0.05
0.08
0.42
Water Speed (kph)
mass in Center
mass in Bow
mass in Stern

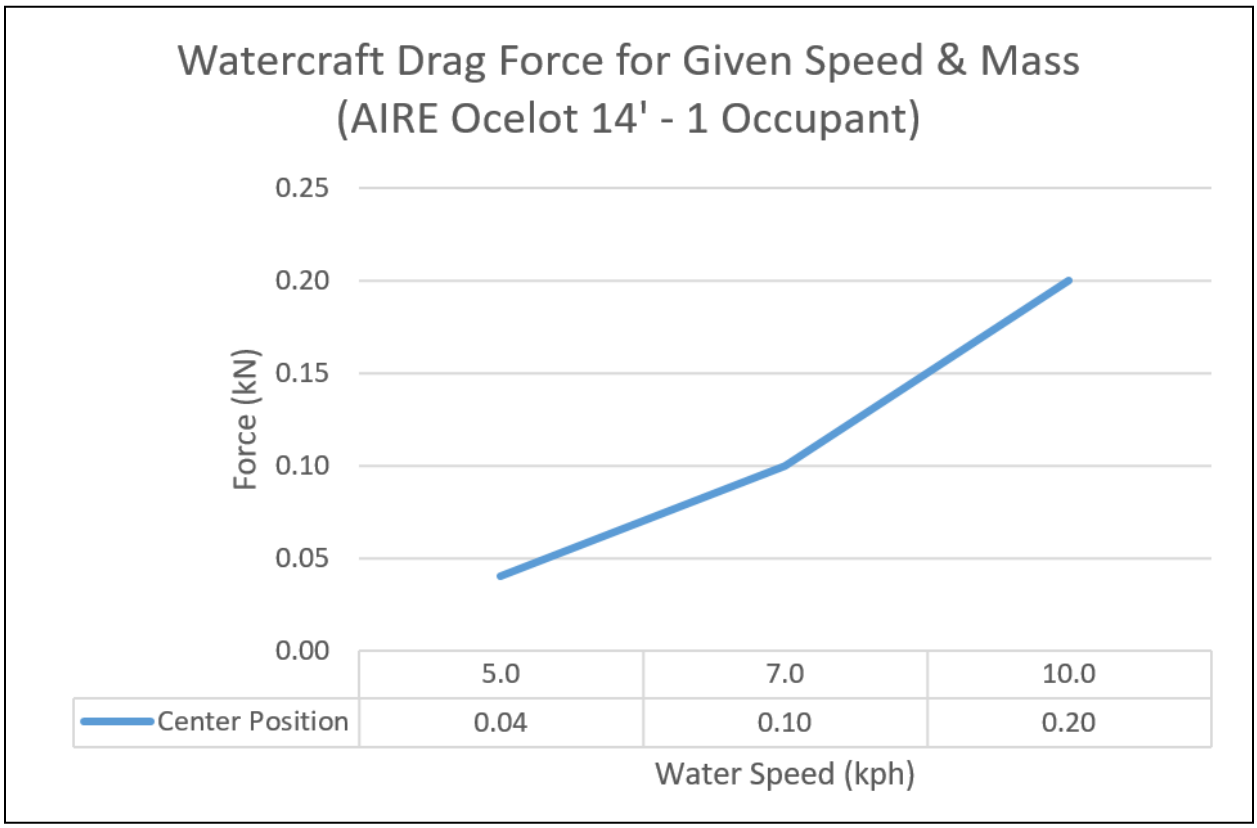

Watercraft Drag Force for Given Speed & Mass
(AIRE E-Series - 2 Occupants)
Chart Area
Series "mass in Stern" Legend Entry
Force (kN)
1.80
1.60
1.20
1.00
0.80
0.60
0.40
0.20
0.00
5.0
7.0
10.0
mass in Center
0.08
0.33
0.33
mass in Bow
0.13
0.52
1.64
mass in Stern
0.06
0.12
0.42
Water Speed (kph)

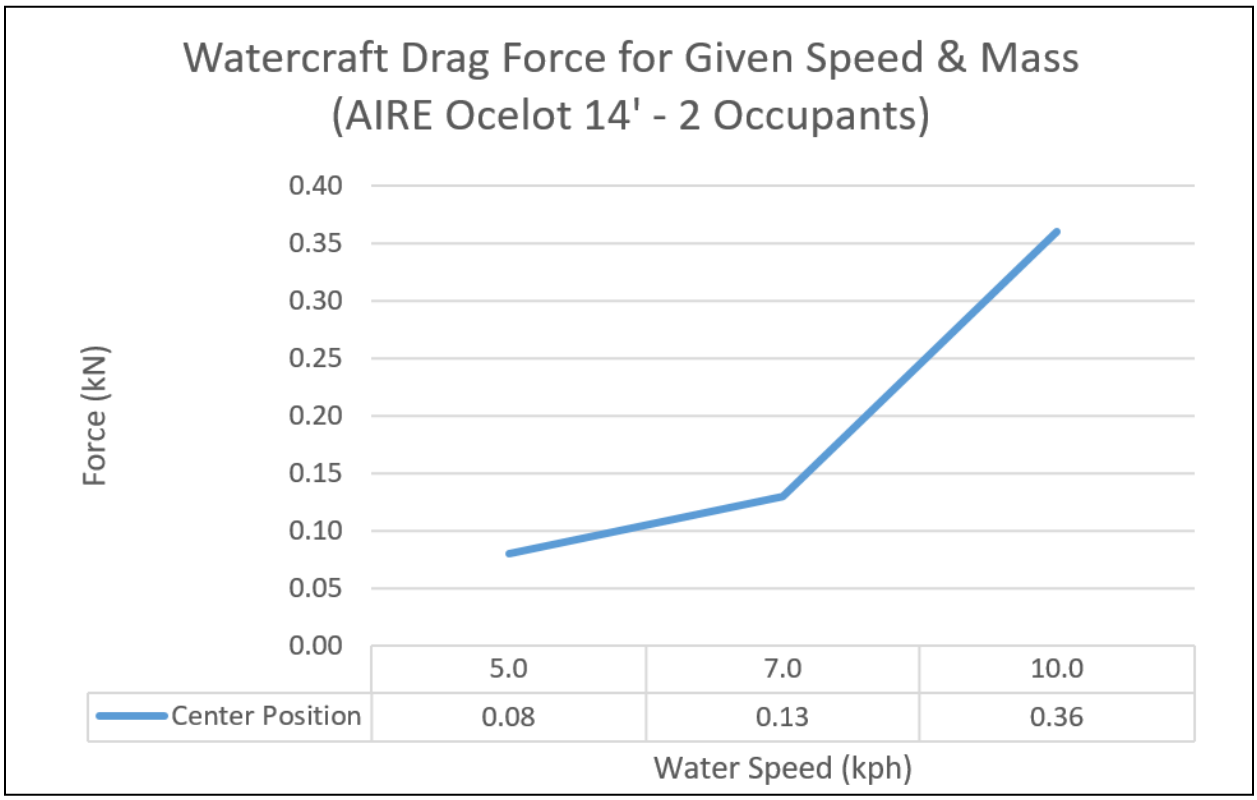

Watercraft Drag Force for Given Speed & Mass
(AIRE E-Series - 3 Occupants)
Force (kN)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
5.0
7.0
10.0
mass in Center 0.05 0.12 0.31
mass in Bow 0.07 0.21 0.63
mass in Stern 0.08 0.23 0.99
Water Speed (kph)
mass in Center
mass in Bow
mass in Stern


Watercraft Drag Force for Given Speed & Mass
(NRS Otter 140 - 2 Occupants)
Force (kN)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
5.0
7.0
10.0
mass in Center 0.06 0.11 0.35
mass in Bow 0.12 0.21 0.59
mass in Stern 0.14 0.35 1.24
Water Speed (kph)
mass in Center
mass in Bow
mass in Stern


Watercraft Drag Force for Given Speed & Mass
(Hyside Cataraft 14' - 1 Occupant)
Force (kN)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5.0
7.0
10.0
mass in Center
0.05
0.07
0.23
mass in Centre - dragging Oar
0.13
0.39
0.39
Water Speed (kph)
mass in Center
mass in Centre - dragging Oar

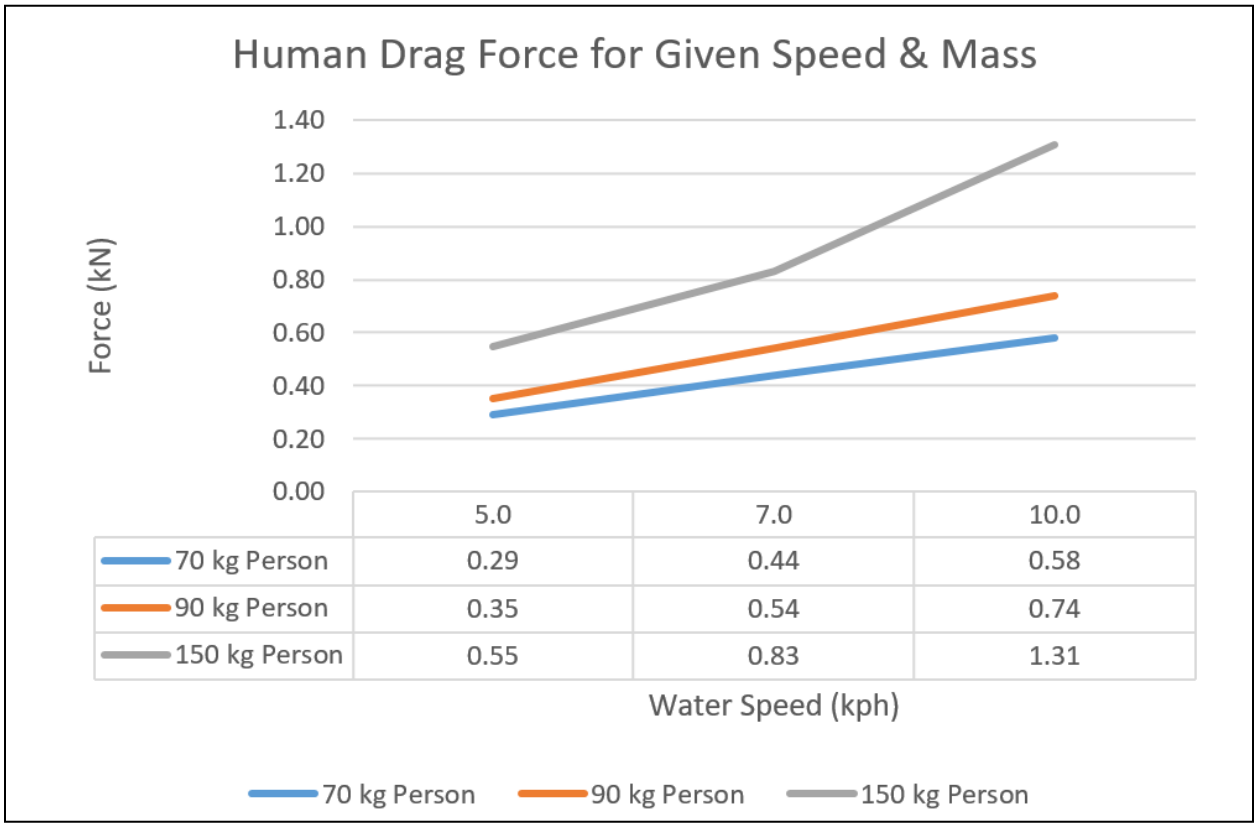

Watercraft Drag Force for Given Speed & Mass
(Hyside Cataraft 14' - 2 Occupants)
Force (kN)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
7.0
10.0
mass in Center
0.13
0.35
Water Speed (kph)
mass in Center


Watercraft Drag Force for Given Speed & Mass
(AIRE Ocelot 14' - 1 Occupant)
Force (kN)
0.25
0.20
0.15
0.10
0.05
0.00
5.0
7.0
10.0
Center Position
0.04
0.10
0.20
Water Speed (kph)


Watercraft Drag Force for Given Speed & Mass
(AIRE Ocelot 14' - 2 Occupants)
Force (kN)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5.0
7.0
10.0
Center Position
0.08
0.13
0.36
Water Speed (kph)

Appendix D: BASECAMP INNOVATIONS LTD 2016

NIF – EMBC/BCSARA Swiftwater Testing Project: Drag Force Test Graphs



BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160818

Temp: 23°C RH: 32%

Testers: KM, CA, HM

DAQ Speed: 500 Hz

Test # 1 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1355	**Test Setup:** 7/16" BW HR3 SN 50570 Lot 7121624 orange MBS 17.3kN Baseline strength test	**Maximum Force Obtained:** 19.731kN
	Comments: File: Test 1 SW 7-16 BW	**Where Failed:** near travelling bollard
Test # 2 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1408	**Test Setup:** 7/16" BW HR3 SN 50570 Lot 7121624 MBS 17.3kN orange Baseline strength test	**Maximum Force Obtained:** 19.594kN
	Comments: File: Test 2 SW 7-16 BW	**Where Failed:** near stationary bollard
Test # 3 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1415	**Test Setup:** 7/16" BW HR3 SN 50570 Lot 7121624 MBS 17.3kN orange Baseline strength test	**Maximum Force Obtained:** 19.757kN
	Comments: File: Test 3 SW 7-16 BW	**Where Failed:** near travelling bollard
Test # 4 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1425	**Test Setup:** 3/8" BW R3 SN 49312 Lot 316167 MBS 15kN yellow/black Baseline strength test	**Maximum Force Obtained:** 17.420kN
	Comments: File: Test 4 SW 3-8 BW	**Where Failed:** near travelling bollard
Test # 5 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1429	**Test Setup:** 3/8" BW R3 SN 49312 Lot 316167 Baseline strength test	**Maximum Force Obtained:** 17.877kN
	Comments: File: Test 5 SW 3-8 BW	**Where Failed:** near stationary bollard
Test # 6 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1434	**Test Setup:** 3/8" BW R3 SN 49312 Lot 316167 Baseline strength test	**Maximum Force Obtained:** 17.969kN
	Comments: File: Test 6 SW 3-8 BW	**Where Failed:** near travelling bollard
Test # 7 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1443	**Test Setup:** 10mm PMI WRR Lot 10B16061G (yellow/blue) MBS 16kN Baseline Strength Test	**Maximum Force Obtained:** 16.297kN
	Comments: File: Test 7 10mm PMI WRR It settled into the cleat twice. Noticeably greater elongation than previous two rope models.	**Where Failed:** near middle

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160818

Temp: 22°C RH: 32%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 8 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1448	Test Setup: 10mm PMI WRR Lot 10B160616 (yellow/blue) MBS 16kN Baseline Strength Test	Maximum Force Obtained: 14.661kN
	Comments: File: Test 8 10mm PMI WRR Settled into cleats twice. Noticeably greater elongation than previous two rope models	Where Failed: near middle
Test # 9 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1455	Test Setup: 10mm PMI WRR Lot 10B160616 (yellow/blue) MBS 16kN Baseline Strength Test	Maximum Force Obtained: 15.422kN
	Comments: File: Test 9 10mm PMI WRR Settled into cleats twice. Noticeably greater elongation than previous two rope models	Where Failed: near stationary bollard
Test # 10 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1503	Test Setup: 5/16" Esprit River Line Baseline Strength Test Yellow/red MBS 14.2kN yellow/red	Maximum Force Obtained: 15.303kN
	Comments: File: Test 10 Esprit 3-8 Spectrex WSL12S-1079 order 18613 ~~Metadata on file incorrect. Should read 3/8" spectrex.~~ ?Any spectra in it? WSL 5/16 WSL140916.516	Where Failed: nearer stationary bollard
Test # 11 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1518	Test Setup: 5/16" Esprit River Line Baseline Strength Test	Maximum Force Obtained: 15.125kN
	Comments: File: Test 11 Esprit 5-16 see test 10	Where Failed: near stationary bollard
Test # 12 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1526	Test Setup: 5/16" Esprit River Line Baseline Strength Test	Maximum Force Obtained: 15.498kN
	Comments: File: Test 12 Esprit 5-16 see test 10	Where Failed: near travelling bollard
Test # 13 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1545	Test Setup: 7/16" CMC River Rescue Rope Baseline Strength Test yellow/blue MBS 16.5kN	Maximum Force Obtained: 24.392kN
	Comments: Temp 19°C RH 42% File: Test 13 CMC 7-16	Where Failed: near travelling bollard
Test # 14 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1550	Test Setup: 7/16" CMC River Rescue Rope Baseline Strength Test	Maximum Force Obtained: 24.386kN
	Comments: File: Test 14 CMC 7-16	Where Failed: near travelling bollard

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160818

Temp: 19°C RH: 40%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 15 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1556	Test Setup: 7/16" CMC River Rescue Rope Baseline Strength Test	Maximum Force Obtained: 24.985kN
	Comments: File: Test 15 CMC 7-16	Where Failed: near stationary bollard
Test # 16 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1605	Test Setup: 7/16" BW Sure Grip Baseline Strength Test Yellow/red MBS 15.1kN	Maximum Force Obtained: 19.654kN
	Comments: File: Test 16 BW Sure Grip 7-16	Where Failed: near travelling bollard
Test # 17 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1610	Test Setup: 7/16" BW Sure Grip Baseline Strength Test	Maximum Force Obtained: 19.642kN
	Comments: File: Test 17 BW Sure Grip 7-16	Where Failed: near stationary bollard
Test # 18 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1619	Test Setup: 7/16" BW Sure Grip Baseline Strength Test	Maximum Force Obtained: 19.552kN
	Comments: File: Test 18 BW Sure Grip 7-16	Where Failed: near travelling bollard
Test # 19 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1627	Test Setup: 1/2" Sterling Waterline Baseline Strength Test Red/yellow W12709 0046 H2-071814JRG MBS 25.6	Maximum Force Obtained: 30.258
	Comments: File: Test 19 Sterling Waterline 1-2	Where Failed: near travelling bollard
Test # 20 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1633	Test Setup: 1/2" Sterling Waterline Baseline Strength Test	Maximum Force Obtained: 29.894kN
	Comments: File: Test 20 Sterling Waterline 1-2	Where Failed: between bollards
Test # 21 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1639	Test Setup: 1/2" Sterling Waterline Baseline Strength Test	Maximum Force Obtained: 29.576kN
	Comments: File: Test 21 Sterling Waterline 1-2	Where Failed: near travelling bollard

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160818

Temp: 17°C RH: 50%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 22 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1646	**Test Setup:** 1/2" Bluewater HR3 Baseline Strength Test Yellow/orange SN 50242 Lot 620168 MBS 22.2 **Comments:** File: Test 22 BW HR3 1-2	**Maximum Force Obtained:** 26.339kN **Where Failed:** near travelling bollard
Test # 23 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1652	**Test Setup:** 1/2" Bluewater HR3 Baseline Strength Test **Comments:** File: Test 23 BW HR3 1-2	**Maximum Force Obtained:** 26.810kN **Where Failed:** near travelling bollard
Test # 24 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1658	**Test Setup:** 1/2" Bluewater HR3 Baseline Strength Test **Comments:** File: Test 24 BW HR3 1-2	**Maximum Force Obtained:** 27.402kN **Where Failed:** middle
Test # 25 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1757	**Test Setup:** 3/8" All Line Baseline Strength Test Yellow/red WSL12S-1079 Order 18613 16145 - Mexico **Comments:** File: Test 25 All Line 3-8, Three distinct, similar force peaks, solid braid core jacketed by thick sheath	**Maximum Force Obtained:** 10.846kN **Where Failed:** middle
Test # 26 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1806	**Test Setup:** 3/8" All Line Baseline Strength Test **Comments:** File: Test 26 All Line 3-8 Appears core is slipping within sheath after inspection of core and sheath	**Maximum Force Obtained:** 11.061kN **Where Failed:** near stationary bollard
Test # 27 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1812	**Test Setup:** 3/8" All Line Baseline Strength Test **Comments:** File: Test 27 All Line 3-8 Elongation was not uniform,	**Maximum Force Obtained:** 10.930kN **Where Failed:** near stationary bollard
Test # 28 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1820	**Test Setup:** 1/2" Bluewater R3 Rescue line Baseline Strength Test MBS 17.8kN SN 50116 Lot 5101616 Yellow/black **Comments:** File: Test 28 BW R3 1-2	**Maximum Force Obtained:** 24.730kN **Where Failed:** near travelling bollard

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160818

Temp: 19°C RH: 46%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 29 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1825	Test Setup: 1/2" Bluewater R3 Rescue Line Baseline Strength Test	Maximum Force Obtained: 24.768kN
	Comments: File: Test 29 BW R3 1-2	Where Failed: near travelling bollard
Test # 30 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1832	Test Setup: 1/2" Bluewater R3 Rescue Line Baseline Strength Test	Maximum Force Obtained: 25.055kN
	Comments: File: Test 30 BW R3 1-2	Where Failed: near travelling bollard
Test # 31 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1848	Test Setup: 7/16" BW HR3 SN50570 Lot 7121624 orange MBS 17.3 kN Knotted strength test (figure 8)	Maximum Force Obtained: 12.389 kN
	Comments: File: Test 31 BW HR3 7-16 knotted	Where Failed: standing part entering knot
Test # 32 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1857	Test Setup: 7/16" BW HR3 Knotted Strength Test	Maximum Force Obtained: 16.094kN
	Comments: File: Test 32 BW HR3 7-16 knotted	Where Failed: standing part entering knot
Test # 33 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1900	Test Setup: 7/16" BW HR3 Knotted Strength Test	Maximum Force Obtained: 16.414kN
	Comments: File: Test 33 BW HR3 7-16 knotted	Where Failed: standing part entering knot
Test # 34 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1906	Test Setup: 3/8" BWR3 SN H9312 Lot 316167 MBS 15kN Yellow/black Knotted strength test	Maximum Force Obtained: 14.777 kN
	Comments: File: Test 34 BW HR3 7-16 knotted	Where Failed: standing part entering knot
Test # 35 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1910	Test Setup: 3/8" BWR3 Knotted strength test	Maximum Force Obtained: 14.749kN
	Comments: File: Test 35 BW HR3 7-16 knotted	Where Failed: standing part entering knot

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160818

Temp: 21°C RH: 43%

Testers: KM, CA, HM

DAQ Speed: 500 Hz

Test # 36 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1914	Test Setup: 3/8" BW R3 Knotted Strength Test	Maximum Force Obtained: 12.819 kN
	Comments: File: Test 36 BW HR3 7-16 knotted	Where Failed: standing part entering knot
Test # 37 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1920	Test Setup: 10mm PMI WRR Lot 10B16061G yellow/blue MBS 16kN Knotted Strength Test	Maximum Force Obtained: 10.653 kN
	Comments: File: Test 37 PMI 10mm WRR knotted core is black core appeared to fail prior to sheath	Where Failed: standing part entering knot
Test # 38 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1925	Test Setup: 10mm PMI WRR Knotted StrengthTest	Maximum Force Obtained: 11.773 kN
	Comments: File: Test 38 PMI 10mm WRR knotted core is black core appeared to fail prior to sheath	Where Failed: standing part entering knot
Test # 39 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1928	Test Setup: 10mm PMI WRR Knotted Strength Test	Maximum Force Obtained: 10.221 kN
	Comments: File: Test 39 PMI 10mm WRR knotted core is black core appeared to fail prior to sheath	Where Failed: standing part entering knot
Test # 40 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1934	Test Setup: 5/16" Esprit River Line Knotted Strength Test Yellow/red MBS 14.2kN WSL12S-1079 order 18613	Maximum Force Obtained: 10.117 kN
	Comments: File: Test 40 Esprit 5-16 knotted	Where Failed: standing part entering knot
Test # 41 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1938	Test Setup: 5/16" Esprit River Line Knotted Strength Test	Maximum Force Obtained: 9.455 kN
	Comments: File: Test 41 Esprit 5-16 knotted	Where Failed: standing part entering knot
Test # 42 ☑ Pre Photo ☐ ~~Post Photo~~ video Time: 1941	Test Setup: 5/16" Esprit River Line Knotted Strength Test	Maximum Force Obtained: 10.018 kN
	Comments: File: Test 42 Esprit 5-16 knotted	Where Failed: standing part entering knot

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160818

Temp: 21°C RH: 40%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 43 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1947	**Test Setup:** 7/16" CMC River Rescue Rope Knotted Strength Test Yellow/blue MBS 16.5kN	**Maximum Force Obtained:** 18.818kN
	Comments: File: Test 43 CMC 7-16 RRR knotted	**Where Failed:** standing part entering knot
Test # 44 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1951	**Test Setup:** 7/16" CMC River Rescue Rope Knotted strength test	**Maximum Force Obtained:** 15.804kN
	Comments: File: Test 44 CMC 7-16 RRR Knotted	**Where Failed:** standing part entering knot
Test # 45 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1955	**Test Setup:** 7/16" CMC River Rescue Rope Knotted Strength Test	**Maximum Force Obtained:** 17.372kN
	Comments: File: Test 45 CMC 7-16 RRR Knotted	**Where Failed:** Standing part entering knot
Test # 46 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0904	**Test Setup:** 7/16" BW Sure Grip Knotted Strength Test Yellow/red MBS 15.1kN	**Maximum Force Obtained:** 14.495kN
	Comments: File: Test 46 BW Sure Grip 7-16 knotted Date: 160819 Temp: 16°C RH: 45% Testers: KM, CA, HM DAQ Speed: 500Hz	**Where Failed:** standing part entering knot
Test # 47 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0910	**Test Setup:** 7/16" BW Sure Grip Knotted Strength Test	**Maximum Force Obtained:** 13.325kN
	Comments: File: Test 47 BW Sure Grip 7-16 Knotted	**Where Failed:** standing part entering knot
Test # 48 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0914	**Test Setup:** 7/16" BW Sure Grip Knotted Strength Test	**Maximum Force Obtained:** 14.236kN
	Comments: File: Test 48 BW Sure Grip 7-16 Knotted	**Where Failed:** Standing part entering knot
Test # 49 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0918	**Test Setup:** 1/2" Sterling Waterline Knotted Strength Test Red/Yellow W12709004G H2-071814JRG MBS 25.6kN	**Maximum Force Obtained:** 21.854kN
	Comments: File: Test 49 Sterling 1-2 Waterline knotted	**Where Failed:** Standing part near knot

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160819

Temp: 15°C RH: 54%

Testers: KM, CA, HM

DAQ Speed: 500 Hz

Test # 50 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0922	Test Setup: Rope as before Comments: File: Test 50 Sterling 1-2 Waterline knotted	Maximum Force Obtained: 21.993kN Where Failed: standing part near knot
Test # 51 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0925	Test Setup: Rope as before Comments: File: Test 51 Sterling 1-2 Waterline Knotted	Maximum Force Obtained: 21.181kN Where Failed: standing part near knot
Test # 52 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0931	Test Setup: 1/2" Bluewater HR3 Knotted Strength Test Yellow/orange SN 50242 Lot 620168 MBS 22.2 Comments: File: Test 52 BW HR3 1-2 knotted	Maximum Force Obtained: 21.950kN Where Failed: standing part near knot
Test # 53 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0935	Test Setup: Rope as before Comments: File: Test 53 BW HR3 1-2 knotted	Maximum Force Obtained: 20.614kN Where Failed: standing part near knot
Test # 54 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0938	Test Setup: Rope as before Comments: File: Test 54 BW HR3 1-2 knotted	Maximum Force Obtained: 19.255kN Where Failed: standing part near knot
Test # 55 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0942	Test Setup: 3/8" All Line Knotted Strength Test Yellow/red WSL125-1079 Order 18613 Comments: File: Test 55 All Line 3-8 knotted	Maximum Force Obtained: 10.205kN Where Failed: standing part near knot
Test # 56 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 0946	Test Setup: Rope as before Comments: File: Test 56 All Line 3-8 knotted	Maximum Force Obtained: 10.940kN Where Failed: standing part near knot

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160819

Temp: 22°C RH: 45%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 57 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 0950	Test Setup: Rope as before	Maximum Force Obtained: 11.425kN
	Comments: File: Test 57 All Line 3-8 Knotted	Where Failed: standing part near knot
Test # 58 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 0956	Test Setup: 1/2" BW R3 Rescue Line Knotted Strength Test MBS 17.8kN SN50116 lot5101616 Yellow/black	Maximum Force Obtained: 16.233kN
	Comments: File: Test 58 BW R3 1-2	Where Failed: standing part near knot
Test # 59 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 0959	Test Setup: Rope as before	Maximum Force Obtained: 16.265kN
	Comments: File: Test 59 BW R3 1-2	Where Failed: standing part near knot
Test # 60 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1003	Test Setup: Rope as before	Maximum Force Obtained: 20.489kN
	Comments: File: Test 60 BW R3 1-2 Max force ~4kN greater than previous tests	Where Failed: Standing part near knot
Test # 61 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1144	Test Setup: Rope 1 7/16" BW HR3 BW3W 5mm Titan Prusik	Maximum Force Obtained: 9.983kN
	Comments: File: Test 61 Rope 1 Titan 5mm Prusik settled in, did not slip	Where Failed: Failed at termination knot.
Test # 62 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1302	Test Setup: 7/16" BW HR3 BW3W 5mm Titan Prusik see legend	Maximum Force Obtained: 9.707kN
	Comments: File: Test 62 Rope 1 Titan 5mm Trial test: 2 wraps slipped in bollards	Where Failed: no failure
Test # 63 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1305	Test Setup: Repeat Test 62 with same prusik and rope.	Maximum Force Obtained: 14.816kN
	Comments: File: Test 63 Rope 1 Titan 5mm	Where Failed: Prusik pinched rope in two

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 130819

Temp: 20°C RH: 37%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 64 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1310	Test Setup: Rope 1 CMC 6mm	Maximum Force Obtained: 7.157kN
	Comments: File: Test 64 Rope 1 cmc 6mm subsequent slips at ~6.5kN, regripping at ~3.5kN	Where Failed: prusik slipped
Test # 65 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1316	Test Setup: Rope 1 CMC 7mm	Maximum Force Obtained: 9.000kN
	Comments: File: Test 65 Rope 1 cmc 7mm subsequent slips at ~6.5kN	Where Failed: prusik slipped
Test # 66 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1325	Test Setup: Rope 2 Titan 5mm	Maximum Force Obtained: 12.386kN
	Comments: File: Test 66 Rope 2 Titan 5mm	Where Failed: prusik pinched rope in two
Test # 67 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1329	Test Setup: Rope 2 CMC 6mm	Maximum Force Obtained: 9.911kN
	Comments: File: Test 67 Rope 2 CMC 6mm	Where Failed: prusik settled in, popped sheath at 9.911kN, failed core 6kN
Test # 68 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1333	Test Setup: Rope 2 CMC 7mm	Maximum Force Obtained: 10.273kN
	Comments: File: Test 68 Rope 2 CMC 7mm	Where Failed: prusik settled in popped sheath at 10.273kN failed core at 7kN
Test # 69 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1338	Test Setup: Rope 3 Titan 5mm	Maximum Force Obtained: 12.843kN
	Comments: File: Test 69 Rope 3 Titan 5mm	Where Failed: prusik pinched rope in two
Test # 70 ☑ Pre Photo ☑ ~~Post Photo~~ Time: video 1342	Test Setup: Rope 3 CMC 6mm (should read 6mm)	Maximum Force Obtained: 11.775kN
	Comments: File: Test 70 Rope 3 CMC ~~7~~ 6mm first slippage ~7.5kN, second ~9kN, third ~10kN	Where Failed: Standing rope entering hitch

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160819

Temp: 21°C RH: 34%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 71 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1347	Test Setup: Rope 3 cmc 7mm	Maximum Force Obtained: 12.150 kN
	Comments: File: Test 71 Rope 3 cmc 7mm initial slip ~7.5kN, then ~10kN	Where Failed: standing rope entering hitch
Test # 72 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1352	Test Setup: Rope 4 Titan 5mm	Maximum Force Obtained: 5.411 kN
	Comments: File: Test 72 Rope 4 Titan 5mm ongoing slippage at ~3.3kN	Where Failed: prusik slipped
Test # 73 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1357	Test Setup: Rope 4 cmc 6mm Test 73	Maximum Force Obtained: 5.643kN
	Comments: File: Rope 4 cmc 6mm regrab consistent at ~3.5kN first slip ~3.6kN, then ~4kN, then ~4.6kN, then ~5.2kN ~5.6kN	Where Failed: prusik slipped
Test # 74 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1401	Test Setup: Rope 4 cmc 7mm Test 74	Maximum Force Obtained: 6.180kN
	Comments: File: Rope 4 cmc 7mm reg 3 first ~4.3kN, then ~4.4kN, ~4.7kN, ~5.2-6.2	Where Failed: prusik slipped
Test # 75 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1408	Test Setup: Rope 5 Titan 5mm Test 75	Maximum Force Obtained: 13.404kN
	Comments: File: Rope 5 Titan 5mm	Where Failed: double fisherman pulled end through
Test # 76 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1413	Test Setup: Rope 5 cmc 6mm Test 76	Maximum Force Obtained: 12.847 kN
	Comments: File: Rope 6 cmc 6mm first slip ~9.3kN, ~11.5kN	Where Failed: Prusik slipped twice then pinched rope in two
Test # 77 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1421	Test Setup: Rope 5 cmc 7mm Test 77	Maximum Force Obtained: 12.868kN
	Comments: File: Rope 5 cmc 7mm	Where Failed: prusik slipped twice then popped sheath at ~12.3kN

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - *Equipment Testing 2016*

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160820

Temp: 22°C RH: 32%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 78 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1428	Test Setup: Rope 6 Titan 5mm	Maximum Force Obtained: 11.693kN
	Comments: File: Rope 6 Titan 5mm Test 78	Where Failed: prusik pinched rope in two
Test # 79 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1432	Test Setup: Rope 6 cmc 6mm	Maximum Force Obtained: 7.784kN
	Comments: File: Rope 6 cmc 6mm Test 79 continued slippage at ~3.5kN	Where Failed: prusik slipped at max first
Test # 80 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1436	Test Setup: Rope 6 cmc 7mm	Maximum Force Obtained: 8.106kN
	Comments: File: Test 80 Rope 6 cmc 7mm continued to slip ~4.5-5kN	Where Failed: prusik slipped at max force
Test # 81 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1443	Test Setup: Rope 7 Titan 5mm	Maximum Force Obtained: 12.517kN
	Comments: File: Test 81 Rope 7 Titan 5mm	Where Failed: end of double fisherman pulled through
Test # 82 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1447	Test Setup: Rope 7 cmc 6mm	Maximum Force Obtained: 8.430kN
	Comments: File: Test 82 Rope 7 cmc 6mm initial slip 8.4kN, subsequent at ~7kN, re-gsips at ~4kN	Where Failed: prusik slipped at max force
Test # 83 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1452	Test Setup: Rope 7 cmc 7mm	Maximum Force Obtained: 13.416kN
	Comments: File: Test 83 Rope 7 cmc 7mm	Where Failed: tore sheath at peak
Test # 84 ☑ Pre Photo ☑ ~~Post Photo~~ video Time: 1515	Test Setup: Rope 8 Titan 5mm	Maximum Force Obtained: 17.249kN
	Comments: File: Test 84 Rope 8 Titan 5mm	Where Failed: tail pulled through triple fishermans

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160819

Temp: 22°C RH: 32%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 85 ☑ Pre Photo ☑ Post Photo Time: video 1520	Test Setup: Rope 8 cmc 6mm	Maximum Force Obtained: 11.156kN
	Comments: File: Test 85 Rope 8 cmc 6mm subsequent slips ~5.5-7kN	Where Failed: prusik slipped
Test # 86 ☑ Pre Photo ☑ Post Photo Time: video 1525	Test Setup: Rope 8 cmc 7mm	Maximum Force Obtained: 12.338kN
	Comments: File: Test 86 Rope 8 cmc 7mm subsequent slips ~6-8.5kN	Where Failed: prusik slipped
Test # 87 ☑ Pre Photo ☑ Post Photo Time: video 1535	Test Setup: Rope 9 Titan 5mm	Maximum Force Obtained: 6.934kN
	Comments: File: Test 87 Rope 9 Titan 5mm	Where Failed: Sheath failed under prusik
Test # 88 ☑ Pre Photo ☑ Post Photo Time: video 1539	Test Setup: Rope 9 cmc 6mm	Maximum Force Obtained: 5.120kN
	Comments: File: Test 88 Rope 9 cmc 6mm	Where Failed: prusik slipped
Test # 89 ☑ Pre Photo ☑ Post Photo Time: video 1543	Test Setup: Rope 9 cmc 7mm	Maximum Force Obtained: 5.568kN
	Comments: File: Test 89 Rope 9 cmc 7mm initial slip ~5.6kN, subsequent ~3-4kN	Where Failed: prusik slipped
Test # 90 ☑ Pre Photo ☑ Post Photo Time: video 1551	Test Setup: ~~Rope 10~~ Titan 5mm Error: Rope used was CMC SRT Throwline 3/8"	Maximum Force Obtained: 10.295kN
	Comments: File: Test 90 Rope 10 Titan 5mm initial slip ~7kN, ~8.5kN	Where Failed: Sheath failed
Test # 91 ☑ Pre Photo ☑ Post Photo Time: video 1555	Test Setup: ~~Rope 10 cmc 6mm~~ Error: Rope Used was CMC SRT Throwline 3/8"	Maximum Force Obtained: 9.149 kN
	Comments: File: Test 91 Rope 10 cmc 6mm initial slip ~6kN, ~7.3kN	Where Failed: Sheath failed

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: 160819

Temp: 23°C RH: 31%

Testers: KM, CA, HM

DAQ Speed: 500Hz

Test # 92 ☑ Pre Photo ☑ Post Photo Time: video 1559	**Test Setup:** ~~Rope 10 CMC 7mm~~ Error: rope used was CMC SRT 3/8" Throwline	**Maximum Force Obtained:** 8.909kN
	Comments: File: Test 92 - Rope 10 CMC 7mm Initial slip ~7.5kN	**Where Failed:** Sheath at prusik
Test # 93 ☑ Pre Photo ☑ Post Photo Time: 16:31	**Test Setup:** Rope 10 (1/2" BW R3); BW 5mm Titan Prusik	**Maximum Force Obtained:** 16.273 kN
	Comments: Rope Failed at Prusik entry (standing part)	**Where Failed:** Standing part entering Prusik
Test # 94 ☑ Pre Photo ☑ Post Photo Time: 16:35	**Test Setup:** Rope 10 (1/2" BW R3); CMC 6mm Prusik	**Maximum Force Obtained:** 11.817 kN
	Comments: Sheath failed after Prusik settled-in; then core failed at ≈10 kN	**Where Failed:** Sheath failed, then core
Test # 95 ☑ Pre Photo ☑ Post Photo Time: 16:39	**Test Setup:** Rope 10 (1/2" BW R3); CMC 7mm Prusik	**Maximum Force Obtained:** 13.118 kN
	Comments: Sheath failed at ≈13 kN, then core at ≈ 8 kN	**Where Failed:** Standing part entering Prusik
Test # 96 ☑ Pre Photo ☑ Post Photo Time: 18:16	**Test Setup:** CMC Throwline Redi-Line 7/16" Knotted	**Maximum Force Obtained:** 8.336kN
	Comments: File # 96... knotted	**Where Failed:** standing part entering Fig 8
Test # ~~97~~ ☑ Pre Photo ☑ Post Photo Time: 18:21	**Test Setup:** same rope as 96; 6mm CMC Prusik	**Maximum Force Obtained:** 4.941 kN
	Comments: Slipped at 4.9 kN, then constantly at 2.2 ≈ 2.8 kN	**Where Failed:** Prusik slipped
Test # 98 ☑ Pre Photo ☑ Post Photo Time: 18:25	**Test Setup:** Same rope as 96; 7mm CMC Prusik	**Maximum Force Obtained:** 5.799 kN
	Comments: slipped first at 5.8kN, then steady @ 3-3.2 kN	**Where Failed:** Prusik slipped

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: Aug 19, 2016

Temp: 23°C RH: 30%

Testers: CA ; KM

DAQ Speed: 500 Hz

Test # 99 ☑ Pre Photo ☑ Post Photo Time: 18:31	**Test Setup:** BW sure Grip 3/8, knotted (fig 8)	**Maximum Force Obtained:** 8.401 kN
	Comments: failed at knot	**Where Failed:** standing part at fig 8
Test # 100 ☑ Pre Photo ☑ Post Photo Time: 18:34	**Test Setup:** same rope as 99 ; 6mm CMC Prusik (3W)	**Maximum Force Obtained:** 5.149 kN
	Comments: Prusik 1st slipped at 5.1kN, then at ≃ 2.2-2.8 kN	**Where Failed:** Prusik slipped
Test # 101 ☑ Pre Photo ☑ Post Photo Time: 18:38	**Test Setup:** same rope as #99; 7mm CMC Prusik (3W)	**Maximum Force Obtained:** 6.5 kN
	Comments: Prusik 1st slipped at 6.5 kN, then at ≃ 3.5 kN	**Where Failed:** Prusik slipped
Test # 102 ☑ Pre Photo ☑ Post Photo Time: 18:43	**Test Setup:** CMC Throwline NFPA 3/8" knotted	**Maximum Force Obtained:** 10.113 kN
	Comments: knot failed	**Where Failed:** failed @ standing part of 8
Test # 103 ☑ Pre Photo ☑ Post Photo Time: 18:47	**Test Setup:** CMC NFPA Throwline 3/8" 6mm Prusik	**Maximum Force Obtained:** 3.656 kN
	Comments: —	**Where Failed:** Prusik slipped
Test # 104 ☑ Pre Photo ☑ Post Photo Time: 18:54	**Test Setup:** CMC NFPA Throwline 3/8" ; baseline strength	**Maximum Force Obtained:** 19.104 kN
	Comments: Note: rope was being pulled through cleat	**Where Failed:** dud !
Test # 105 ☑ Pre Photo ☐ Post Photo Time: 19:00	**Test Setup:** repeat of 104	**Maximum Force Obtained:** 18.579 kN
	Comments: rope ends pulled through stopper knots, cleats, and 3 wraps around bollard → through sheath	**Where Failed:** core slipped through sheath

BASECAMP INNOVATIONS LTD.

EMBC Rope Rescue NIF - Equipment Testing 2016

Swiftwater Rescue Systems - Slow Pull Tests

Date: Aug 19, 2016

Temp: 24° **RH:** 29%

Testers: CA; KM

DAQ Speed: 500 Hz

Test #	Test Setup / Comments	Maximum Force Obtained / Where Failed
Test # 106 ☑ Pre Photo ☑ Post Photo Time: 19:06	**Test Setup:** CMC Throwline Redi-Line 7/16" strength Test **Comments:** —	**Maximum Force Obtained:** 12.957 kN **Where Failed:** Traveling bollard
Test # 107 ☑ Pre Photo ☑ Post Photo Time: 19:12	**Test Setup:** BW Sure Grip 3/8" Strength Test (Yellow rope) **Comments:** —	**Maximum Force Obtained:** 11.782 kN **Where Failed:** stationary bollard
Test # ☐ Pre Photo ☐ Post Photo Time:	**Test Setup:** **Comments:**	**Maximum Force Obtained:** **Where Failed:**
Test # ☐ Pre Photo ☐ Post Photo Time:	**Test Setup:** **Comments:**	**Maximum Force Obtained:** **Where Failed:**
Test # ☐ Pre Photo ☐ Post Photo Time:	**Test Setup:** **Comments:**	**Maximum Force Obtained:** **Where Failed:**
Test # ☐ Pre Photo ☐ Post Photo Time:	**Test Setup:** **Comments:**	**Maximum Force Obtained:** **Where Failed:**
Test # ☐ Pre Photo ☐ Post Photo Time:	**Test Setup:** **Comments:**	**Maximum Force Obtained:** **Where Failed:**

Boat Drag Force Tests

Sept 2, 2016

Testers:	mass (with PPE)
Dirk Dorenbos	0.8kN
Chris Armstrong	1.5kN
Chandrima Lavoie	0.7kN
Heather Milligan	
Larry Hanlon	0.9kN
Kirk Mauthner	
Lou Colletti	

Objectives: measure drag force of various swiftwater rescue crafts under various loads and water speeds.

Test Methods & Materials:

- Use Thunderjet, Alexis offshore rescue boat (Nelson SAR) with Twin 150 hp fitted with boom on Port side. RE Enforcer Load cells to measure force
- speed/velocity measurement: Swotter model 2100
  GPS: CPS90
  Boat:

- 3 5 & 10 kph ?

- watercrafts:
  1. Hyside cataraft ; 14'
  2. Tributary 9.5' self-bailing raft ; Aire
  3. Oceanid RDC (rapid deployment craft)
  4. Aire 14' E-Series
  5. Aire 14' Ocelot
  6. NRS 14@ Otter

Variables:

Mass position: Test bow loaded, stern loaded, and in plane

Mass quantity: number of people

Water velocity:

$$\left(\frac{10\,km}{1\,h}\right)\left(\frac{1\,h}{3600\,s}\right)\left(\frac{10\,000\,m}{10\,km}\right) = 2.8\ m/s$$

① Calibrated swoffer 2100 as per manufacturer's "Quick Operating Instructions.

~~swoffer m/s~~

GPS CP590

~~Swoffer~~ reacquisition speed is listed in the manual as <1s

GPS to Swoffer calibration

GPS (km/h)	swoffer ~~(m/s)~~	
	m/s	km/h
	~~2.25~~	
7.3	2.04	7.3
6.8	2.00	7.2
6.9	1.94	6.98
* drifted 6.7	2.01	

Boat Type →	mass →	speed →	position	(5 seconds worth) (range over 5s)
Tributary	~0.7kN	~~4.6~~ km/h	centre	0.03-0.04
		4.5km/h	bow	0.03-0.08
		4.5km/h	stern	0.05-0.09
		7.3	centre	0.09-0.12
		7.0	bow	0.31-0.44
		6.9	stern	0.17-0.32
	~~1.0kN~~	9.9	centre	0.26-0.30
		10.3	bow	0.39-0.45
		9.9	stern	0.62-0.70

Boat Type	Photo time stamp	Mass (kN)	Speed (km/h)	Position	Force (range over 5s)
Tributary		1.6	5.0	centre	0.05 - 0.11
				bow	0.07 - 0.11
				stern	0.11 - 0.18
			7.1	centre	0.12 - 0.14
			7.0	bow	0.71 - 0.78
			7.1	stern	0..29 - 0.3
			10	centre	0 .48 - 0.54
			10	bow	nosedive (max 1.41)
			8.0	bow	nosedive (max 1.65)
			10.0	bow	08.8 - 097 nosedive at 1.17
			10.0	stern	0.97 - 1.03
Oceanid RDC		0.7	5.3	centre	0.03 - 0.05
			5.2-5.8	bow	0.07 - 0.13
			4.5	stern	0.03 - 0.05
			7.1	centre	0.21 - 0.24
			7.0	bow	0.23 - 0.27
			7.0	stern	0.04 - 0.11
			9.8	centre	0.46 - 0.52
			10.0	bow	0.86 - 0.88
			10.4	stern	0.18 - 0.20
		1.6	4.8	centre	0.04 - 0.08
			4.9	bow	0.08 - 0.13
			4.9	stern	0.04 - 0.06
			7.6	centre	0.27 - 0.33
			7.6	bow	0.38 - 0.52
			7.3	stern	0.10 - 0.12
			10.1	centre	0.27 - 0.33

Boat Type	Mass (kN)	Speed (km/h)	mass position	Force (average over 5s) kN
Oceanid RDC	1.6	10.1	bow	1.47 - 1.64
		10.0	stern	0.33 - 0.42
AIRE	0.7	5.0	centre	0.00 - 0.02
		5.0	bow	0.03 - 0.05
		4.9	stern	0.00 - 0.05
		7.1	centre	0.04 - 0.05
		6.8	bow	0.08 - 0.11
		7.1	stern	0.06 - 0.08
		10.1	centre	0.22 - 0.29
		9.8	bow	0.31 - 0.37
		10.0	stern	0.38 - 0.42
	1.6	4.6	centre	0.00 - 0.02
		4.5	bow	0.02 - 0.04
		4.5	stern	0.01 - 0.03
		7.0	centre	0.05 - 0.08
		7.3	bow	0.13 - 0.17
		7.0	stern	0.12 - 0.17
		9.9	centre	0.35 - 0.40
		9.6	bow	0.45 - 0.50
		10.1	bow	0.47 - 0.65
		10.0	stern	0.63 - 0.76
	1.6+	4.4	centre	0.01 - 0.05
		5.0	bow	0.02 - 0.07
		5.2	stern	0.03 - 0.08
		6.9	centre	0.08 - 0.12
		6.9	bow	0.17 - 0.21
		7.0	stern	0.17 - 0.23
		10.1	centre	0.25 - 0.31

Boat Type	Mass (kN)	Speed (km/h)	mass position	Force (kN, range over 5s)
AIRE	1.6+	10.1	bow	0.57 - 0.63
		9.9	stern	0.84 - 0.99
Hyside	0.7	5.3	centre	0.00 - 0.05
		6.9	centre	0.03 - 0.07
		10.1	centre	0.17 - 0.23
		4.7	dragging oar (R)	0.07 - 0.13
		7.7	dragging oar (R)	0.31 - 0.39
		10.0	dragging oar (R)	0.25 - 0.39
	1.6	7.3	centre	0.09 - 0.13
		10.2	centre	0.29 - 0.35
AIRE 14' ocelot	0.7	5.1	centre	0.02 - 0.04
		7.0	centre	0.08 - 0.10
		9.9	centre	0.15 - 0.20
	1.6	4.7	centre/rear	0.05 - 0.08
		7.0	centre/rear	0.10 - 0.13
		10.1	centre/rear	0.33 - 0.36
NRS 142 Otter	0.7 1.6	4.9	centre	0.04 - 0.06
		7.0	centre	0.08 - 0.11
		9.8	centre	0.32 - 0.35
		10.1	bow	0.54 - 0.59
		10.0	stern	1.17 - 1.24
		6.8	bow	0.17 - 0.21
		7.0	stern	0.29 - 0.35
		5.0	stern	0.07 - 0.14
		4.9	bow	0.06 - 0.12

	kN	Speed km/h	Force (kN, range over 5s)
Northwater Rescue PFD w/ person in drysuit, dorsal attachment	0.7	5.1	0.22 - 0.29
		7.0	0.38 - 0.44
		10.3	0.48 - 0.58
	0.9	5.0	0.28 - 0.35
		7.0	0.48 - 0.54
		9.5	0.70 - 0.74
	CA	5.2	0.51 - 0.55
		6.9	0.79 - 0.83
		9.8	1.24 - 1.31