IRB CONVENTIONAL RAFTING DRAG PREDICTIONS

Attachment (a) – Predicted Resistance for Conventional Rafting
Attachment (b) – Waterjet Modeling of Legacy Waterjet

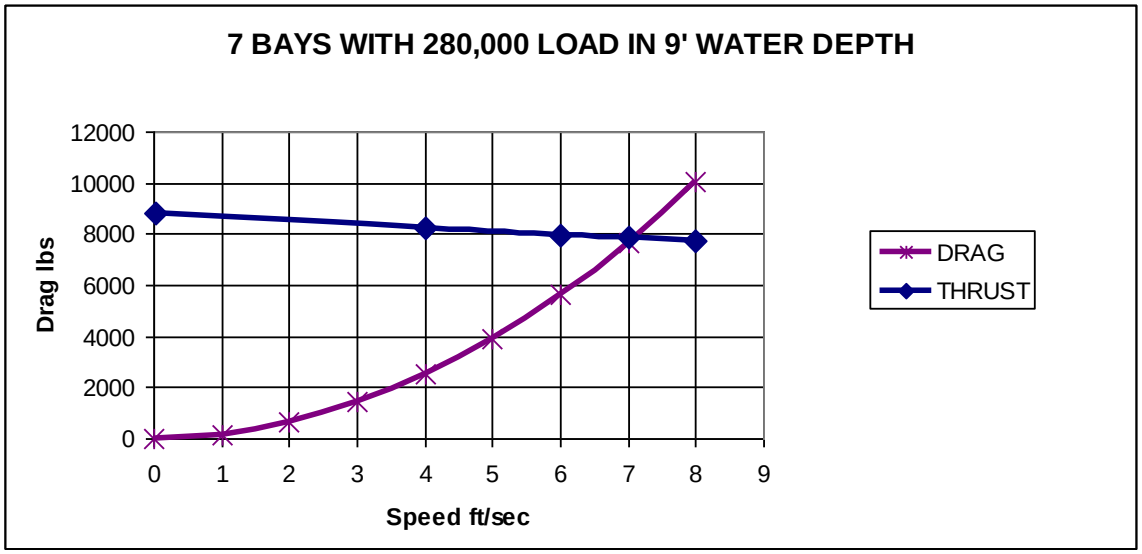
Resistance predictions for conventional rafting of a 7-bay IRB raft loaded with two MLC 70 tracked vehicles is provided in Attachment (a). This type of prediction is commonly used for anchoring and slow speed maneuvering analysis. The predictions are based on United Facilities Criteria (UFC) – Design: Moorings, UFC 4-159-03 Dated 3 Oct 05 (pages 93-100), downloadable at http://www.wbdg.org/ccb/DOD/UFC/ufc_4_159_03.pdf. Resistance is a function of geometry, displacement and water depth. As the water depth decreases in shallow water, resistance increases (water piles up in front of the raft). However, beyond a certain water depth, resistance does not decrease significantly with increased water depth. The calculations do not include any margins or allowances for hull fouling.

When rafting conventionally in 6 feet of water, water will spill over the front of the loaded raft at relative water speeds greater than approximately 7.5 ft/sec. The figure below shows a loaded 7 bay raft operating at relative water speeds significantly higher than 7.5 ft/sec. The relative water speed at which water begins to spill over the front of the raft is dependent on waves, wind, and water depth. Because a larger pile up of water is created when operating in shallow water, water will begin to spill over at slower speeds in shallow water than in deep water. Water spilling over the front of the raft will increase the resistance of the raft. This increase in resistance at high relative water speeds is not accounted for in the resistance predictions provided in Attachment (a).

The waterjet of the legacy BEB is modeled in Attachment (b). The modeling has been calibrated against the recorded bollard pull of the craft (nominal 4,400 pounds for two

jets). Assuming no cavitation breakdown, the thrust of a waterjet at constant power decreases with forward speed. The predicted pushing force at 6 ft / sec is 3,990 pounds per BEB (1,995 pounds per jet). This neglects the small drag of the BEB at this speed.

Using the resistance prediction modeling of attachment a and the waterjet modeling of attachment b, two legacy BEBs are predicted to be able to push a 7 bay raft loaded with 280,000 # of cargo (two MLC70 vehicles) in 9 feet of water at a speed of 7.1 ft / sec as shown in the figure below.



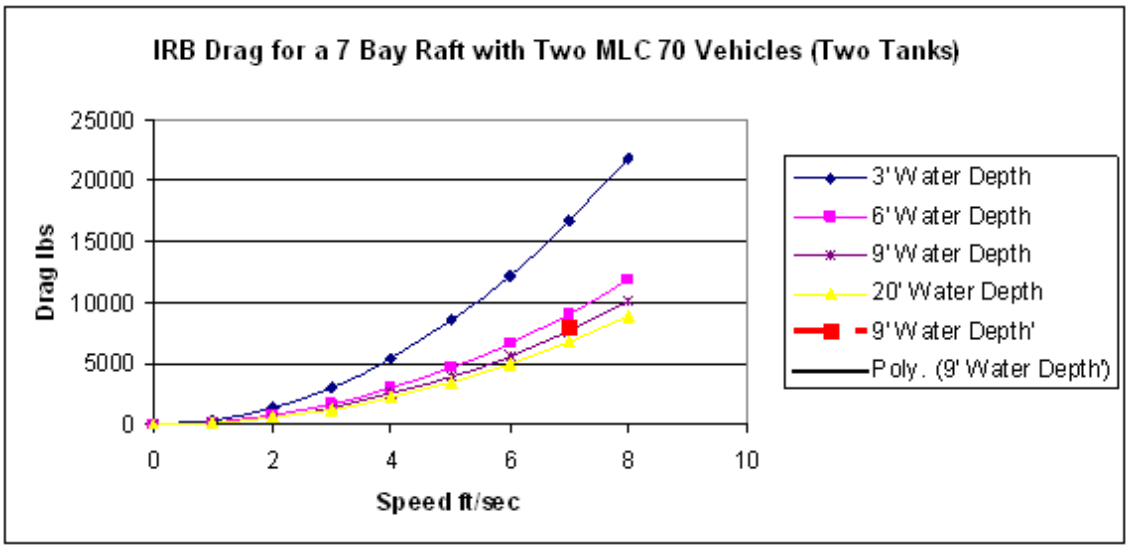
The predicted speed matches the recent conventional rafting tests at Aberdeen and historical data for similar conditions. The average speed for a 7 bay configuration with two tanks tested at Aberdeen on 4 Aug 08 was 6.95 ft / sec, which is within 2 % of the speed predicted.

PREDICTED RESISTANCE FOR CONVENTIONAL RAFTING

UFC 4-159-03 (USN Mooring Handbook) Dated 2005 (pages 93-100)

ATTACHMENT A

2 BEBS PUSHING 7 BAYS WITH A 280,000 # LOAD (2 MLC70 Tracked Vehicles)



Resistance Calculation for 7 Bay Raft, Conventional Rafting, 2 MLC 70 Tracked Vehicles

Bridge pieces	14000 lb each
For 7 pieces	98000 lb
Tank wt	278000 lb
Total wt	376000 lb
Total Length	154 ft
Beam	26 ft
Lto B	5.923077
Draft	1.672117 ft
Area	257.506 ft2
Co	0.535422
C1	3.2
K	2

	Water Speed ft/sec								
Water Depth ft	0	1	2	3	4	5	6	7	8
				Drag in lbs					
1	0	1994.629	7978.516	17951.66	31914.06	49865.73	71806.64	97736.82	127656.3
2	0	598.9609	2395.844	5390.648	9583.375	14974.02	21562.59	29349.08	38333.5
3	0	340.5039	1362.015	3064.535	5448.062	8512.596	12258.14	16684.69	21792.25
4	0	250.0439	1000.176	2250.395	4000.702	6251.097	9001.58	12252.15	16002.81
5	0	208.1738	832.6954	1873.565	3330.781	5204.346	7494.258	10200.52	13323.13
6	0	185.4296	741.7185	1668.867	2966.874	4635.74	6675.466	9086.051	11867.5
9	0	156.7122	626.8487	1410.41	2507.395	3917.804	5641.638	7678.896	10029.58
20	0	138.3904	553.5617	1245.514	2214.247	3459.761	4982.056	6781.131	8856.988
30	0	135.8059	543.2235	1222.253	2172.894	3395.147	4889.011	6654.487	8691.575

WATERJET MODELING OF LEGACY WATERJET

ATTACHMENT B

ESTIMATED WATERJET THRUST FOR MK II BEB

August 08
STANDARD ENGLISH UNITS USED

REF FOR CALCS: MARINE WATERJET PROPULSION, SNAME 1993 ANNUAL

BEB CALCS AT LOW SPEED FULL POWER

NOTE	A	B	C					
JET	ULTRA 300	ULTRA 300	ULTRA 300	ULTRA 300	ULTRA 300	ULTRA 300	ULTRA 300	
NOZZLE								
IMPELLER								
AJ	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
A INLET	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
ELEVATION	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SHAFT ANGL	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
VEL SHIP knots	0.01	2.37	3.56	4.15	4.74	20.00	25.00	14.00
VEL SHIP ft / sec	0.02	4.00	6.01	7.01	8.00	33.76	42.20	23.63
VW (WAKE SP)	0.02	3.84	5.77	6.72	7.68	32.41	40.51	22.69
WAKE	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
THRUST	2200.00	2064.00	1995.00	1961.00	1927.00	1270.00	1080.00	1550.00
HP	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00
VEL JET	61.59	61.60	61.59	61.60	61.60	65.72	67.92	64.26
VEL INLET	23.60	23.61	23.61	23.61	23.61	25.19	26.03	24.63
VEL INLET/SHIP	1398.231	5.901	3.928	3.370	2.950	0.746	0.617	1.042
VEL VW/JET	0.000	0.062	0.094	0.109	0.125	0.493	0.596	0.353