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References

Ashley Book of Knots
Handbook of Mountain Guides Association
Knots – Bill March / Rope Tech
Wilderness First Aid

Kayak – William Nealy
River Rescue – Les Bechdel & Slim Ray
River Safety Anthology – Charlie Waldbridge
Whitewater Rescue Manual – Charles Waldbridge & Wayne Sundmacher Sr.
WhiteWater Safety and Rescue – Franco Ferrero

What Makes Water Powerful?

Flow (volume): _____ measured in cms (cubic meters per second)

Gradient: _____ m/km, %, per mil (feet per mile)

Combined, these two factors determine the speed of the water flowing in the river.

Imperial to Metric Conversions

	Exact	Rule of thumb
Flow	cfs x 0.2832 = cms	cfs / 35 = cms
Gradient	feet per mile x 0.1894 = m/km	fpm / 5 = m / km

Force

$F = \text{constant} * \mathbf{A} * \mathbf{v}^2$

Force = constant * Surface **A**rea * River **V**elocity * River **V**elocity

Personal Rescue Equipment

Throwbag: 8 – 10.5 mm, 15 – 25 m polypropylene or Spectra rope, (1 carabiner always attached at the non-throwing end)

Carabiners: 4 preferably locking

Prusik Loop: 2 loops of 5 – 6 mm static nylon line about 2 m long

Webbing Sling: 1 sling of 1” tubular nylon webbing about 3 m long

Knife: river knife with blunt tip or folding saw

Duct Tape: small roll, coloured

Pulleys: 1 or 2 lightweight climbing pulleys (optional)

Paddle Hook: can be improvised (optional)

Hazards

Physical

- Holes, hydraulic, recirculation, stopper
  - Smile
  - Hole depth
  - Backwash length
  - Aeration
  - Uniformity
  - Logs
- Weirs
- Strainer, sweeper
- Undercuts
- Boulder sieve

Consequences

- Entrapment
- Broaches
- Dislocations
- Long swim
- Flush drowning
- Environmental (hypothermia)

Rope

Dynamic: > 4% stretch
Static: < 4% stretch

Ideal rescue rope qualities

- Floats
- Strong
- Static
- Brightly coloured
- Inexpensive
- Light
- Abrasion resistant
- Soft/pliable
- High melting point
- Size (diameter & length)

Type of Rope	Breaking Strength	Stretch	Heat Resistance	Floats
Polypropylene	-	-	--	++
Climbing Rope	+	-	+	-
Static Nylon Line	++	++	++	-
Spectra	+	+	-	+

Rescue Priorities

General Principles

- Own safety first
- Do NOT add victims
- Try safest, fastest techniques first
- Keep it simple

Safety Priorities

1. Personal safety, do not endanger yourself
2. Other rescuers and bystanders
3. Victim

Consideration for Order of Rescue Procedures

Fast, simple, safe techniques first!

Reach – (hand, paddle, hook, extension)

Throw – (throwbag, tag lines)

Boat – (ferrying, towing, tethered boat rescue)

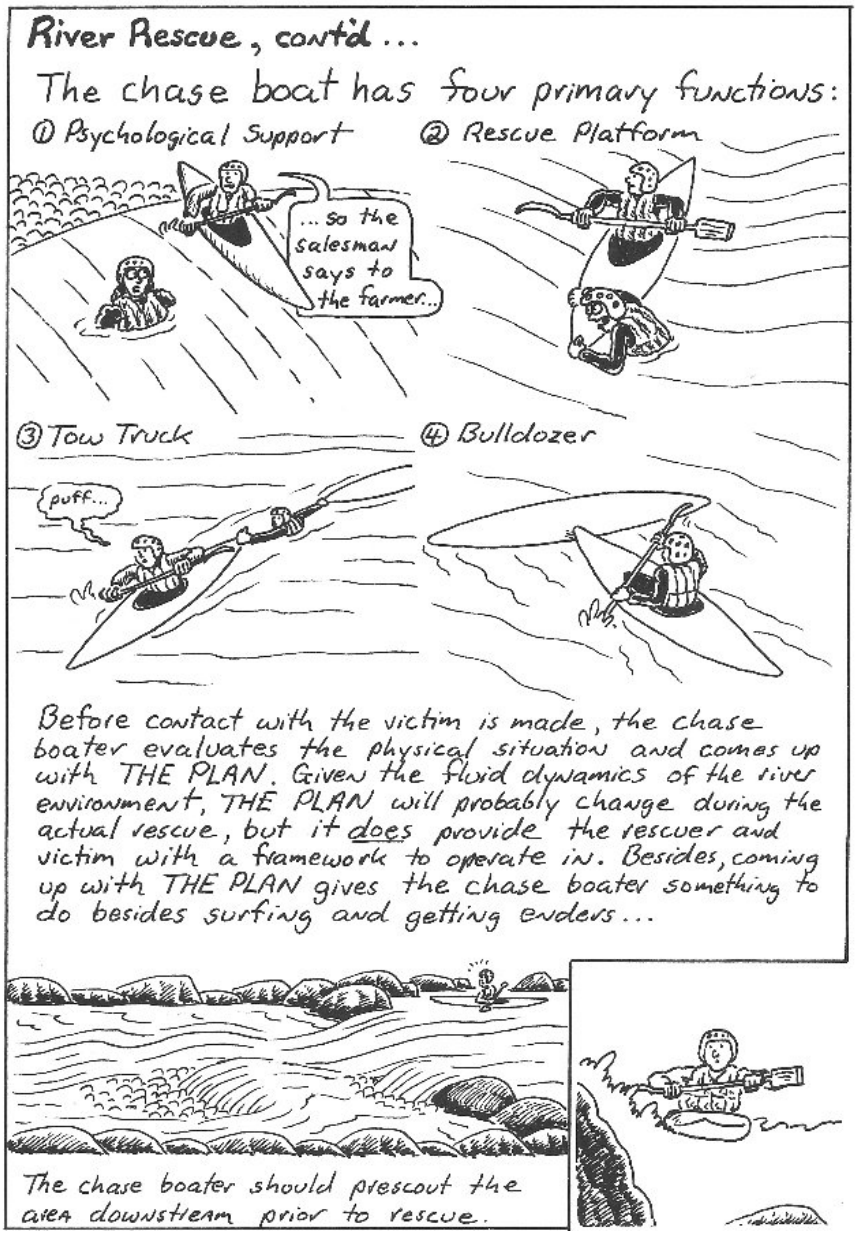
Swim – (strong swimmer, belay)

?? (helicopter, fire truck winches …)

Chase Boating excerpts from Nealy (Page 102-105)

Chase boating Rules:

1. Thou shalt not, by thy efforts, put Thyself and thy swimmer in more danger than the swimmer was originally. (Doctrine of Extra Danger)
2. Thou shalt never make physical contact with any swimmer until Thou hast ascertained the mental state of that same swimmer. (Doctrine of Presumed Insanity)
3. Verily, the Chase Boater is like a god, and the swimmer but a wretched supplicant unto Him/Her. As the naughty dog fears its angry master, so shall the miscreant swimmer fear the wrath of the Chase Boater if His/Her every command is not instantly obeyed. (Doctrine of Supreme Ascendancy of Chase Boaters)



Rescue Organization

Minimum: Leader, Rescuer, Belayer
Ideal: Leader, Asst. Leader, Rescuer(s), Belayer(s), Spotter

Role	Task	Description
Leader	• Organize rescue, assign roles • Take charge	• Experienced, detached • Assigned prior to trip
Assistant Leader	• Replace leader if necessary • Coordinate on opposite shore	• Experienced, detached • Assigned prior to trip
Rescuer	• Performs rescue	• Suited to the task (skilled, light, heavy, strong) • Experienced
2nd Rescuer	• Performs rescue	• Suited to the task (skilled, light, heavy, strong) • Experienced
Belayer	• Secures Rescuer	• Reliable
2nd Belayer	• Secures 2nd Rescuer	• Reliable
Backup	• Provides backup safety for Rescuer and Victim • Usually downstream	• Skills appropriate to situation and technique
2nd Backup	• Same as backup, different technique • possibly on opposite shore	• Skills appropriate to situation and technique
Spotter	• Warns river traffic • Alerts rescuers to floating debris, logs… • Usually upstream	
Runners, Signalers…		

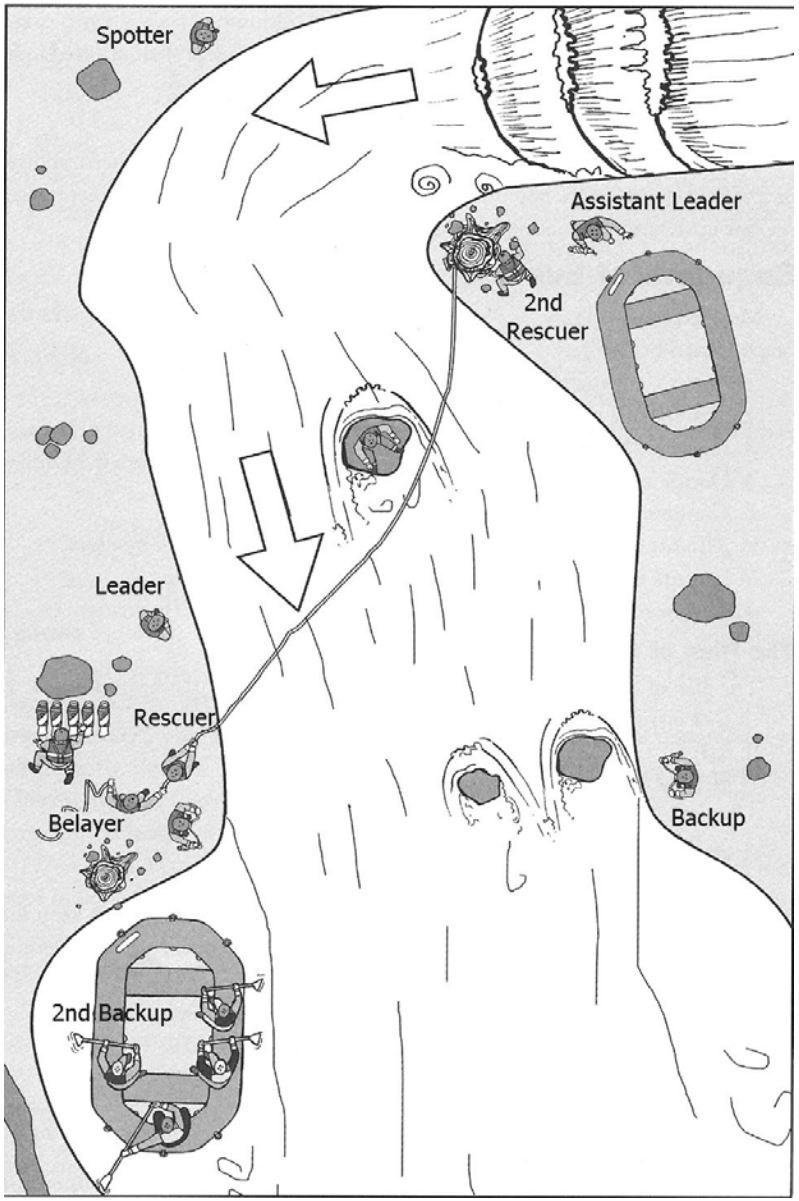


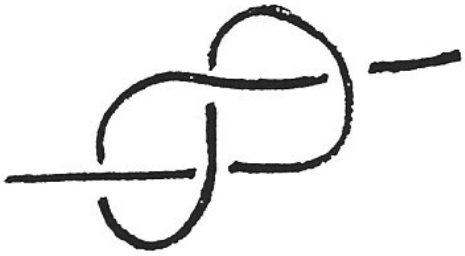
Figure modified from Page 188 White Water Safety and Rescue, Franco Ferrero, 1998

Knots for River Rescue

Purpose	Simple, Fast & Reversible	Secure & Permanent
Stopper	--	Figure Eight
Loop at end of rope	Bow Line	Figure Eight Loop
Loop in middle of rope	Butterfly	--
Connect two ends	Sheet Bend	Double Fisherman
Tie end to fixed	Slip knot	Clove hitch
Connect tube webbing ends	Water knot	--
Specialized	Munther hitch	--
Specialized	Prusik wrap	--

Bowline

Figure Eight



Butterfly

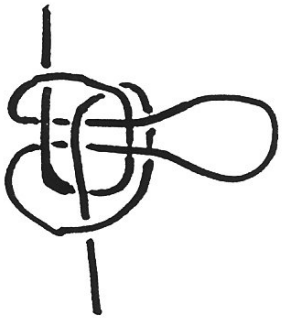
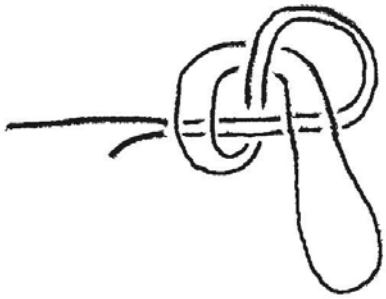
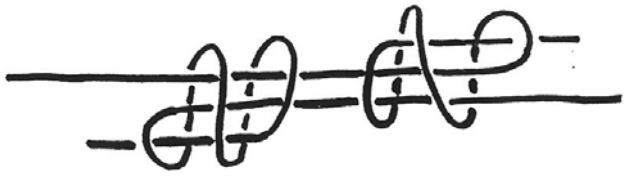


Figure Eight Loop

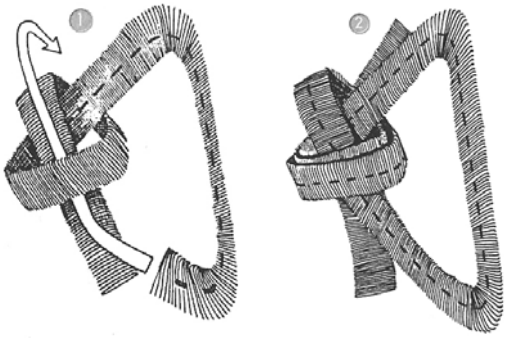


Sheet Bend

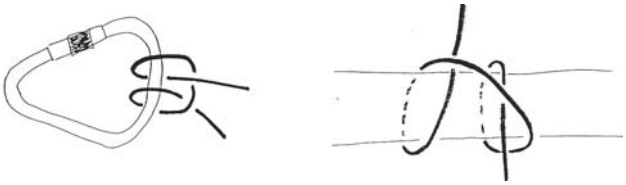
Double Fisherman



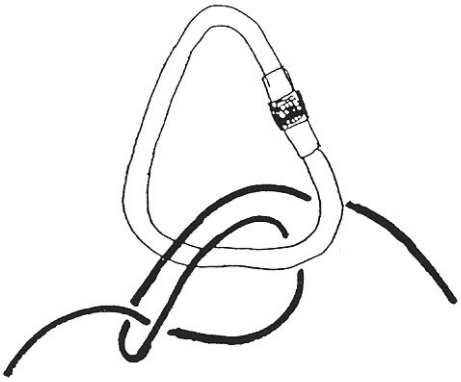
Water Knot



Clove Hitch

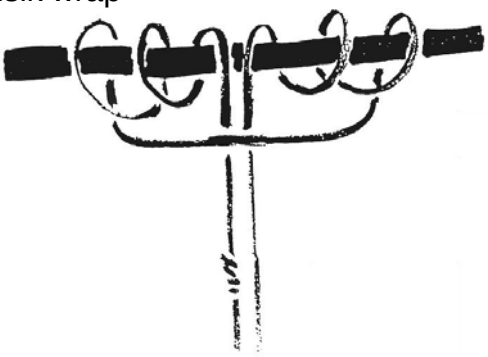


Munther Hitch



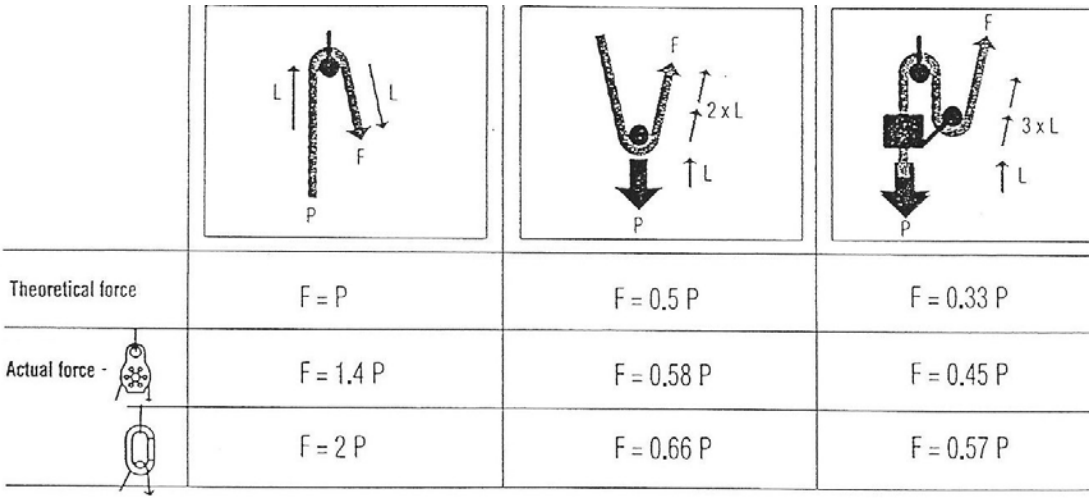
Munther Hitch Secured

Prusik wrap



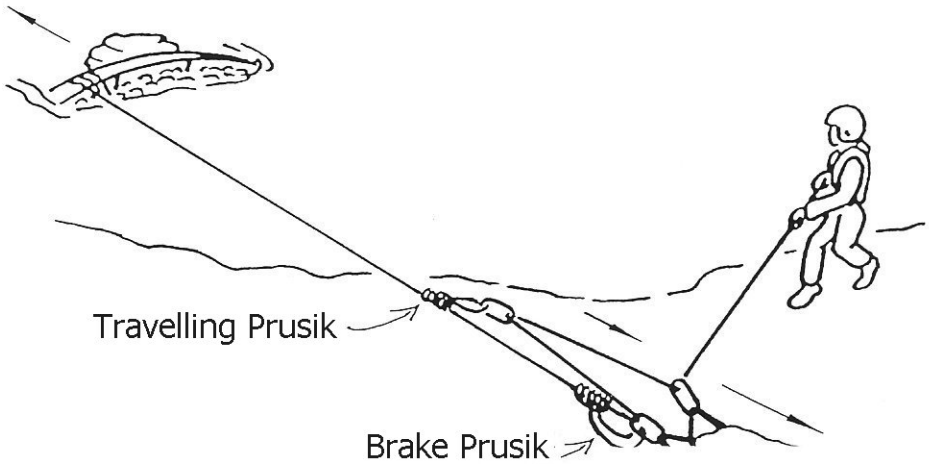
Mechanical Advantage Systems

Mechanical advantage systems are rope systems that utilize the physical principal of the conservation of work. Work is the product of the force and the distance travelled. So it is possible move the same load using less force and a distance to pull. The most basic mechanical advantage system is the C-drag (2:1), outlined in the middle below. The actual force needed is more than 50% because of the friction between the rope and the pulley/ biner. The C-drag uses a single travelling pulley that distributes the load between its two arms. Therefore one has to pull only half the force (theoretically) but twice the length of rope.
On the right below is the Z-drag (3:1). It utilizes two pulleys and two Prusiks. A travelling pulley, travelling Prusik, stationary pulley, and brake Prusik. Theoretically it generates 3 times the force, but in reality the larger number of pulleys/ biners also increased friction.



Theoretical force	F = P	F = 0.5 P	F = 0.33 P
Actual force -	F = 1.4 P	F = 0.58 P	F = 0.45 P
	F = 2 P	F = 0.66 P	F = 0.57 P

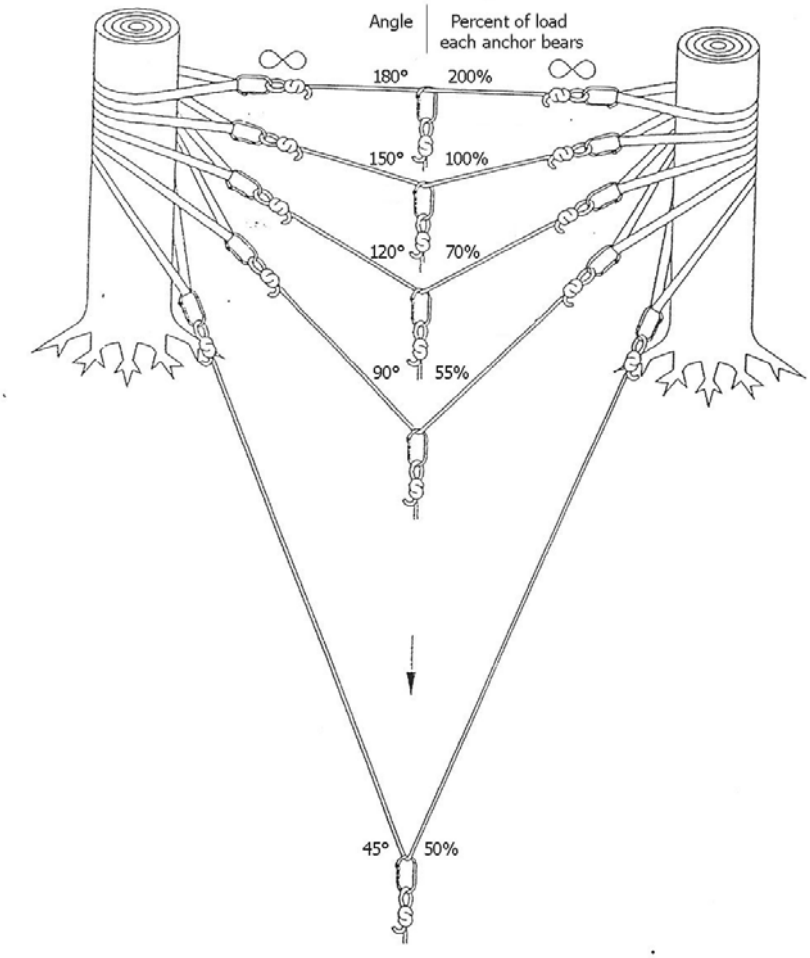
The Z-drag alternates between two states where the load is either on the travelling Prusik when you pull in and shorten the rope, or the load is on the brake Prusik. The latter happens when you stop pulling, and it allows you to move the travelling pulley farther down the rope.



Anchors

We use 1” tubular webbing as anchors for mechanical advantage systems. The anchor should be loosely wrapped around an object, so it can freely rotate if the direction of pull changes. The arms of an anchor should be spread less than 45°. For anchors distributing a load between several attachment points, measure the angle of the outside arms (worst case). If this is angle is exceeded, there is significant additional tension on the system.

This tension can be used and is called a *Vector Pull.* It can be used as an additional mechanical advantage system by pulling perpendicularly on a rope that has already been tensioned, and will produce considerable force.



EARNEST

Equalizing – in a multipoint anchor the load is shared relatively equally
Appropriate Angle – anchor points should make as small an angle as possible
Redundant – if one anchor point fails, what happens?
Non-extending – if one anchor point fails, minimize the travel/ shock load on the remaining anchor(s)
Strong – each individual point should be strong unto itself, to avoid cascading failure
Timely – safe simple anchor construction that doesn’t waste time