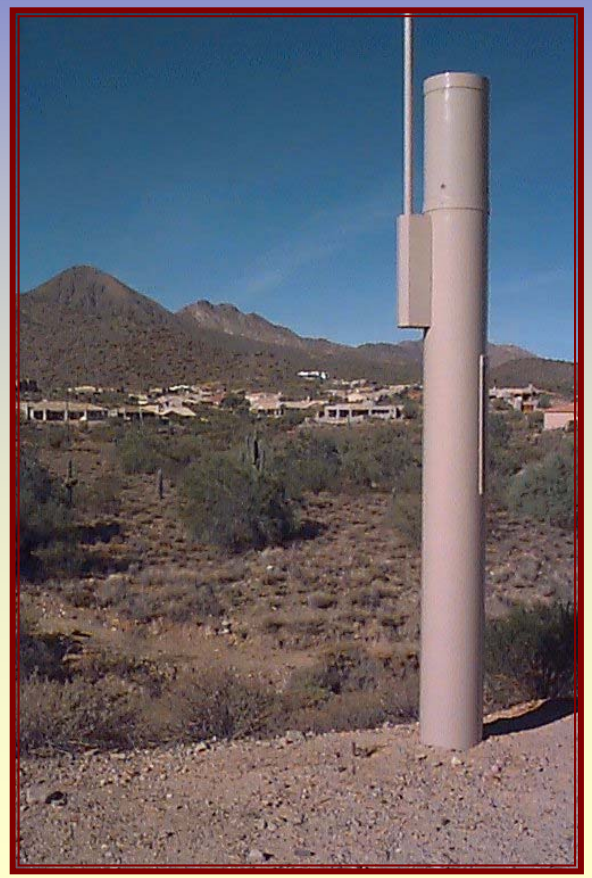
Flood Control District of Maricopa County

Flood Physics



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Physics of Stream Forces

- Moving water exerts pressure on objects.

  Pressure = k(constant) x (Velocity) ^{2}

- Pressure on an area becomes a force.

  Force = (pressure x area)

  water depth ↑ greater area ↑ greater the force

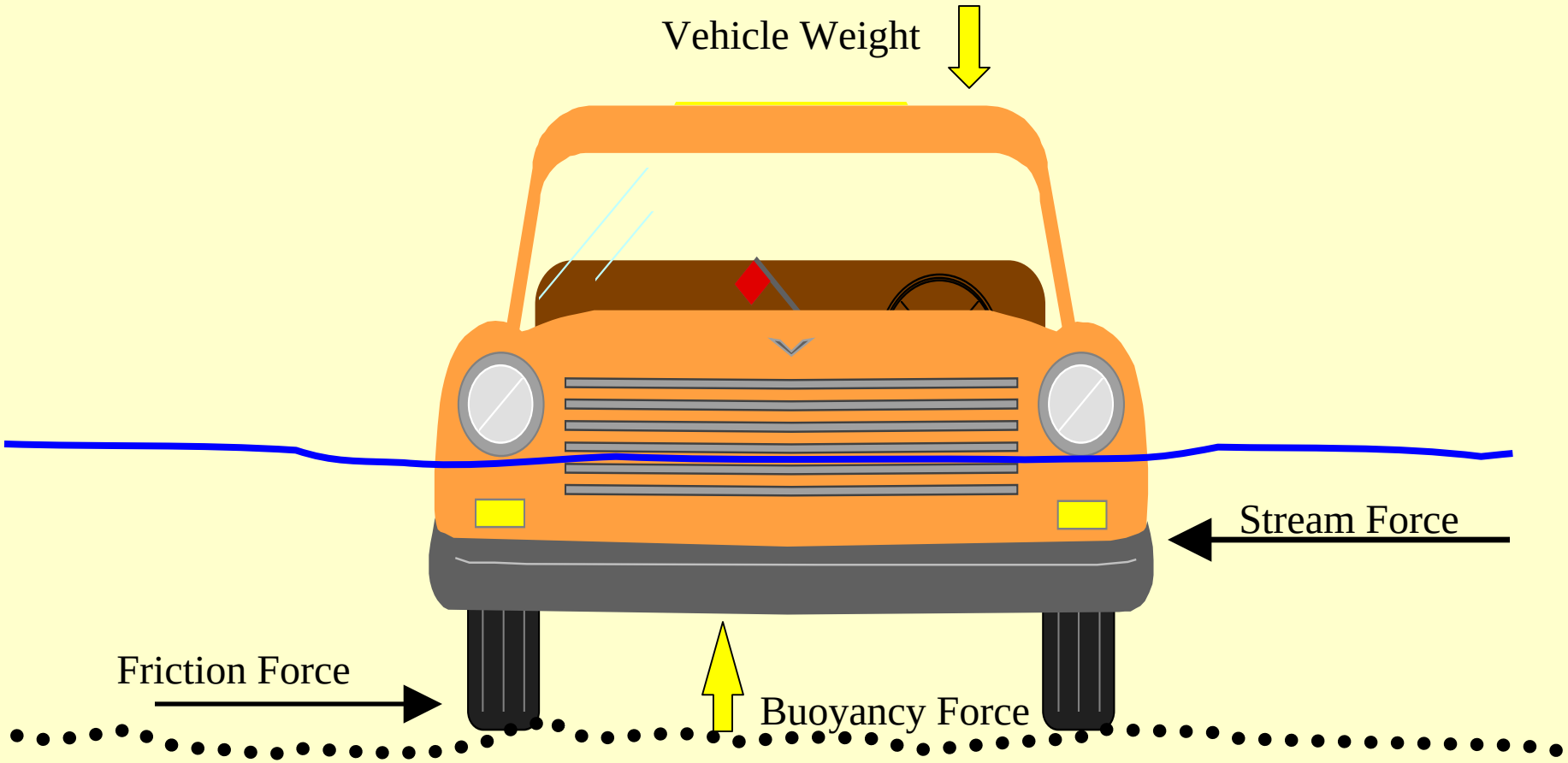
- Surface becomes slippery ↓ (reduced friction force)

Archimedes' Principle

The buoyant force on an object is equal to the weight of the fluid displaced by that object

Forces on Vehicles Crossing Streams

The car will float downstream when:
Stream Force > Friction Force



Some Water Physics Facts

- Water weighs 62.4 pounds/cubic foot, and cars displace a lot of it
- The pressure exerted by moving water increases with the square of its velocity
- Water, sand and mud reduce the frictional forces that hold a car in place
- Water clarity and lighting conditions conceal the condition of the roadway beneath you

From the FEMA Web Page

Flash Floods: How Can a Foot or Two of Water Cost You Your Life?

Nearly *half* of all flash flood fatalities are auto related!

Water weighs 62.4 lbs. per cubic foot and typicallly flows downstream at 6 to 12 miles an hour.

When a vehicle stalls in the water, the water's momentum is trasferred to the car. For each foot the water rises, 500 lbs. of lateral force are applied to the car.

But the biggest factor is buoyancy. For each foot the water rises up the side of the car, the car displaces 1,500 lbs. of water. In effect, the car weighs 1,500 lbs. less for each foot the water rises.

Two feet of water will carry away most automobiles.

Fighting a Losing Battle

- Width: 5.5 feet
- Length: 14 feet
- Ground Clearance: 10 inches
- Weight: 3,400 pounds

However, 1 foot of water displaced by this vehicle weighs:

(5.5’ x 14’ x 1’ x 62.4 lbs./cu.ft.) = 4,805 pounds

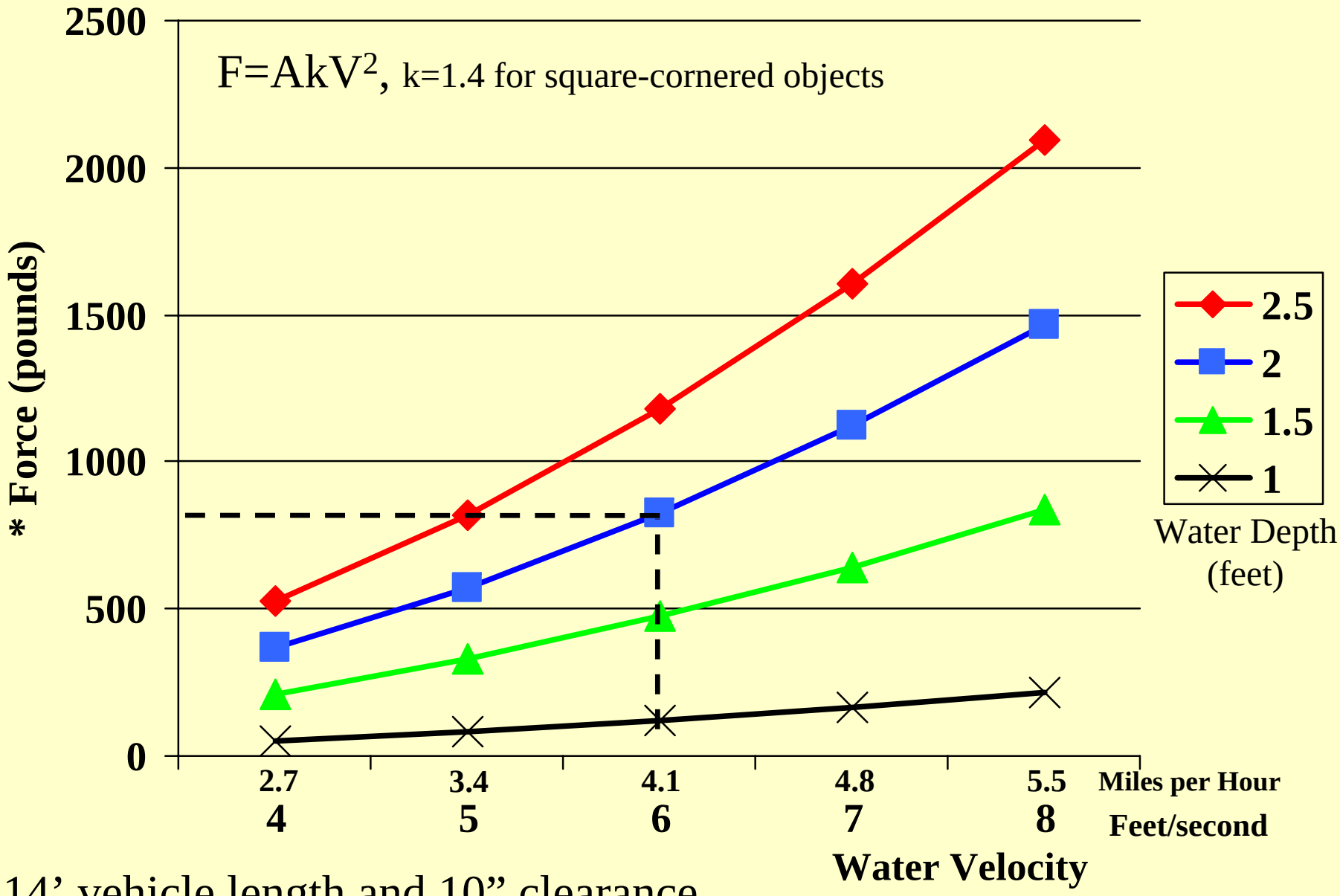
Something a Little Bigger

- Width: 6 feet
- Length: 18 feet
- Ground Clearance: 18 inches
- Weight: 5,040 pounds

1 foot of water displaced by this vehicle weighs:

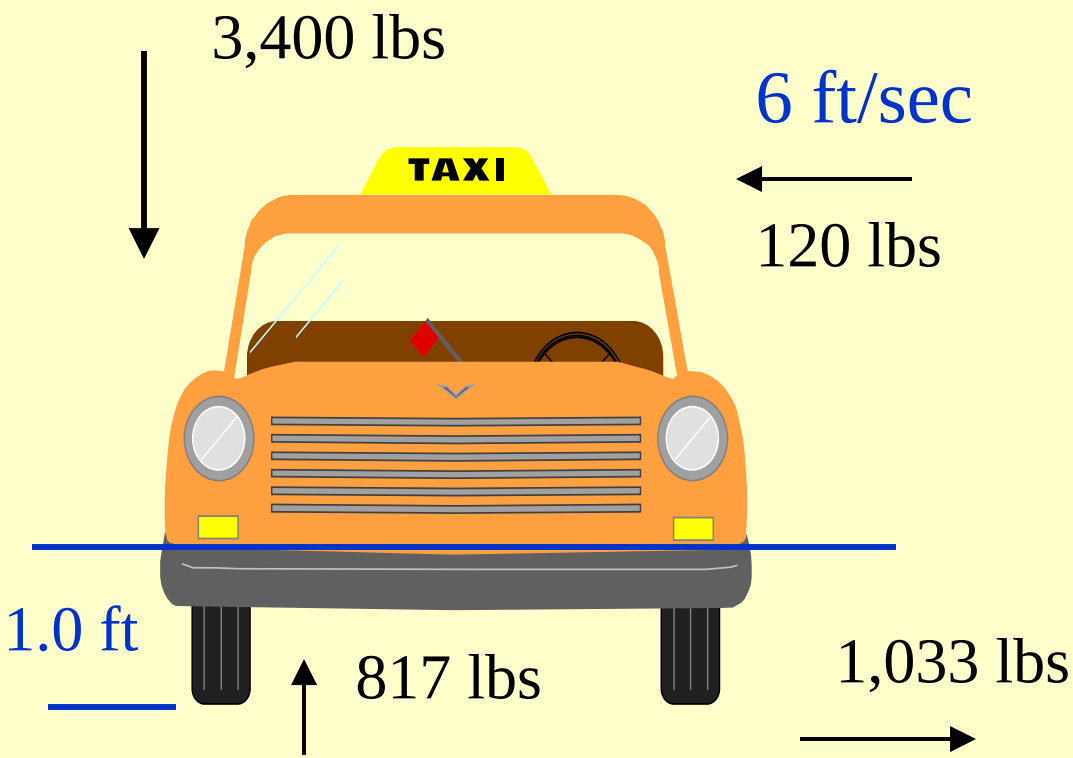
(6’ x 18’ x 1’ x 62.4 lbs./cu.ft.) = 6,739 pounds

Stream Forces on Vehicles



* 14’ vehicle length and 10” clearance

Water Depth: 1 foot



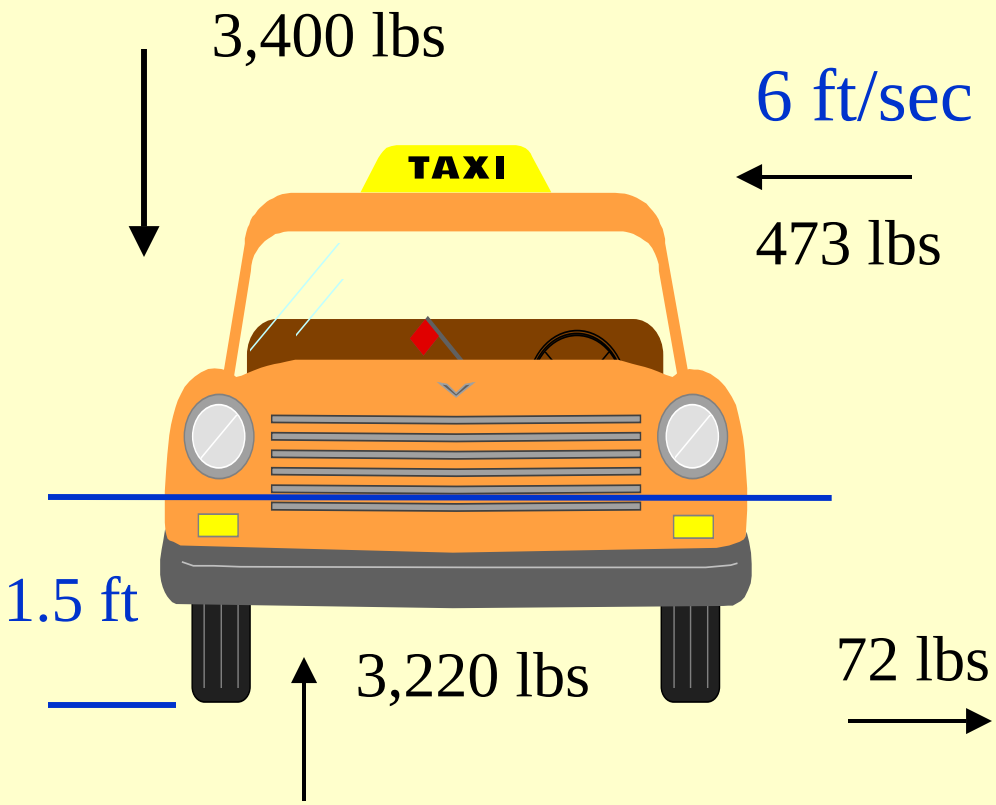
- Width: 5.5 feet
- Length: 14 feet
- Clearance: 10 inches
- Weight: 3,400 pound
- Net Depth = 0.17 feet

Net Weight : 3,400 lbs - 817 lbs = 2,583 lbs

Friction Force: 0.4 x 2,583 lbs = 1,033 lbs

1,033 lbs is greater than the 120 lbs of stream force, so the vehicle stays put

Water Depth: 1.5 feet



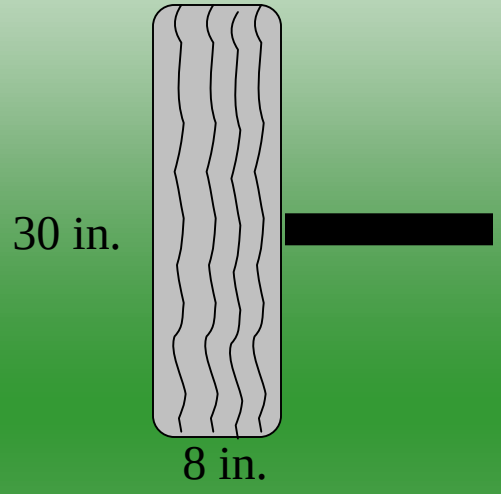
- Width: 5.5 feet
- Length: 14 feet
- Clearance: 10 inches
- Weight: 3,400 pound
- Net Depth = 0.67 feet

Net Weight : 3,400 lbs - 3,220 lbs = 180 lbs

Friction Force: 0.4 x 180 lbs = 72 lbs

72 lbs is less than the 473 lbs of stream force, so the vehicle moves downstream

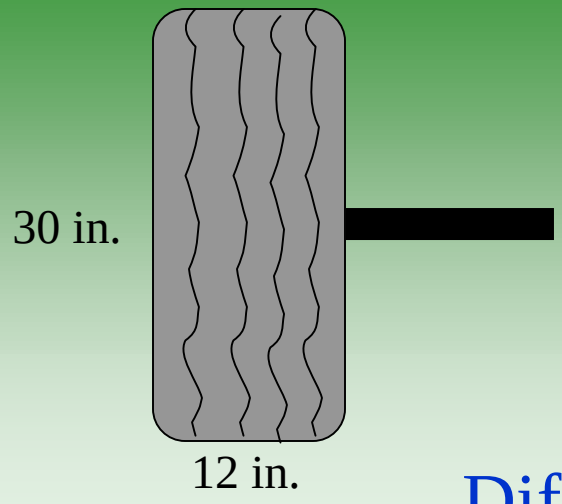
Something Else to Think About



Buoyancy and Tire Size

Volume = 3.27 ft^3/tire x 4 = 13.09 ft^3

13.09 ft^3 * 62.4 lbs/ft^3 = 816.2 lbs

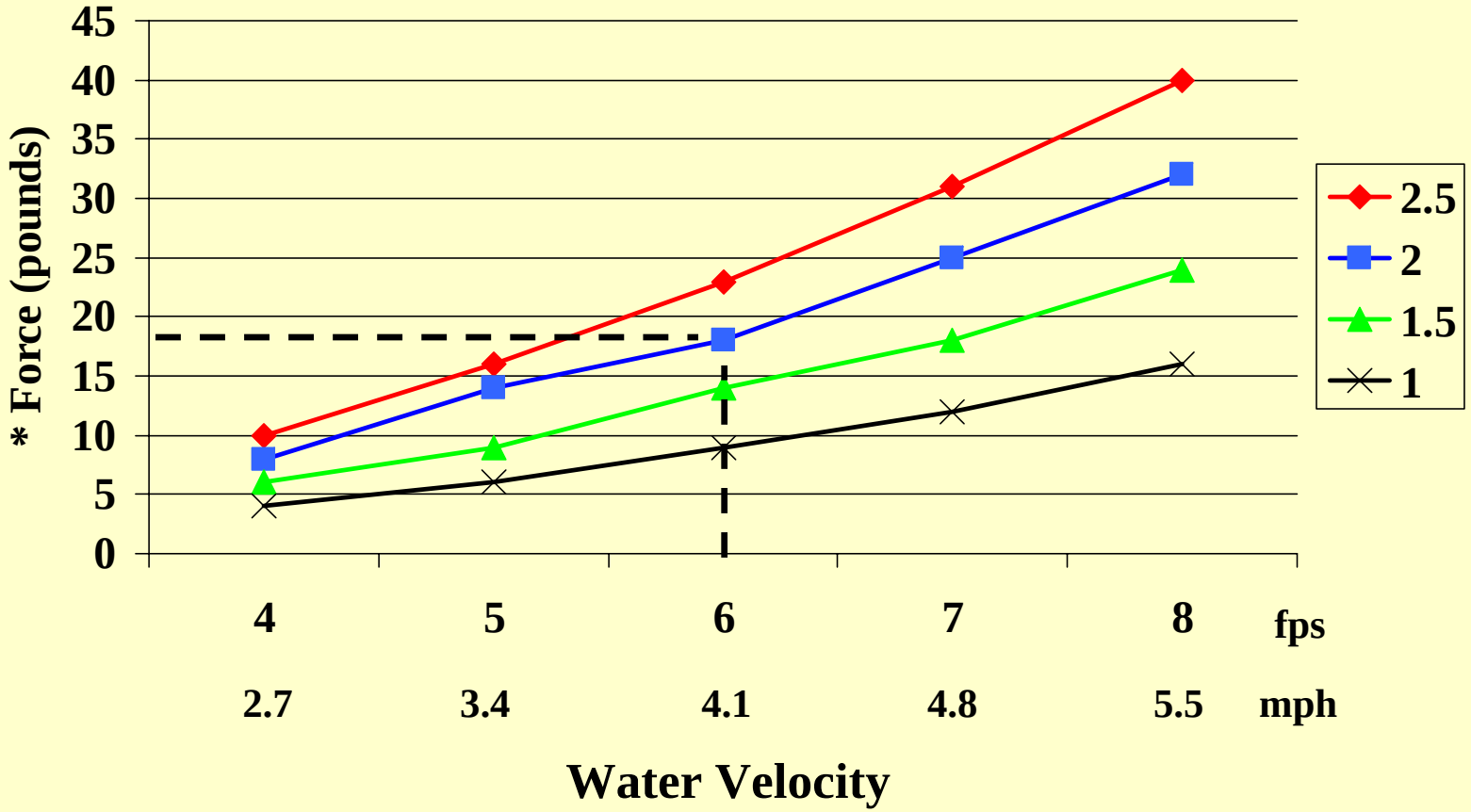


Volume = 4.91 ft^3/tire x 4 = 19.64 ft^3

19.64 ft^3 * 62.4 lbs/ft^3 = 1,225.2 lbs

Difference is 409 lbs. added buoyant force

Stream Forces on Humans



* Force on each leg

Flood Safety

- Judgement
  - If You Absolutely Must Cross a Flooded Stream...
    - Enter slowly, watch the depth and back out if the front axle is submerged
    - If your vehicle stalls in the wash, and upstream weather conditions are bad, abandon the vehicle and get to shore

Flood Safety

- Remember...
- Floodwaters can conceal a damaged roadway
- Flash Floods rarely last more than an hour
- Don’t trade an hour for a lifetime