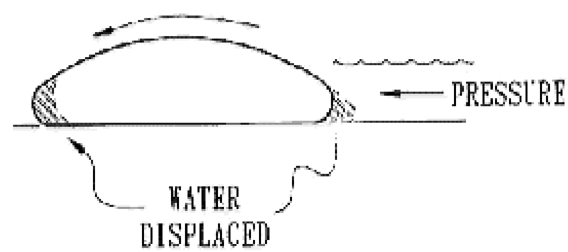
Technical Overview:

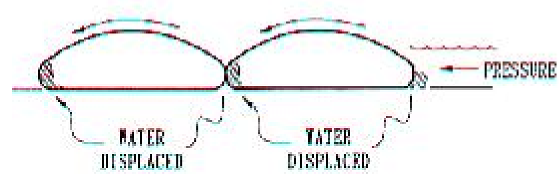
AquaDams® are environmentally safe, stable water barriers used to contain, divert, and control the flow of water. The design consists of two polyethylene liners contained by a single woven geo-tech outer tube. When the two inner tubes are filled with water, the resulting pressure and mass create a stable, non-rolling wall of water.

A single tube filled with water will not provide a stable wall or dam. As the water builds up on one side of the tube the pressure on the wall of the tube begins to increase.

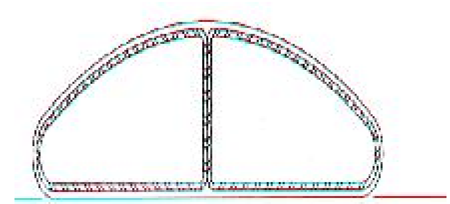
As a result of the building pressure, the water is pushed from one side of the tube to the other side where the pressure remains low. As the water continues to move from one side to the other, the tube begins to roll.



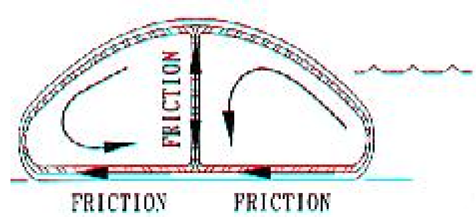
Two water-filled tubes or columns placed side-by-side will assume their natural shapes. If pressure is applied to one side, the water is displaced in the first tube and causes it to roll. As the first tube rolls, it pushes on the second tube moving the water from one side to the other and the two tubes roll together.



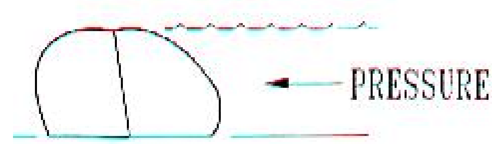
The AquaDam® is able to offer a stable wall by containing two water columns in a single outer tube. The contained water columns are unable to assume their natural position and form a vertical wall in the middle as they press against each other. The pressure inside the tubes applies a substantial force to both sides of this vertical wall.



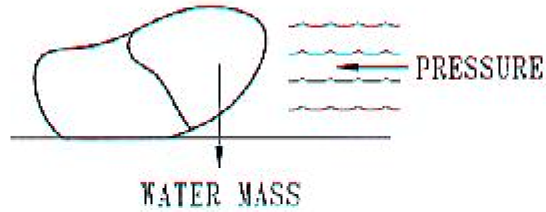
As water pressure begins to build on one side of the AquaDam®, the inner tube naturally tries to roll. However, the friction between the vertical walls and between the inner and outer tubes opposes the rolling tendency and the structure remains fixed.

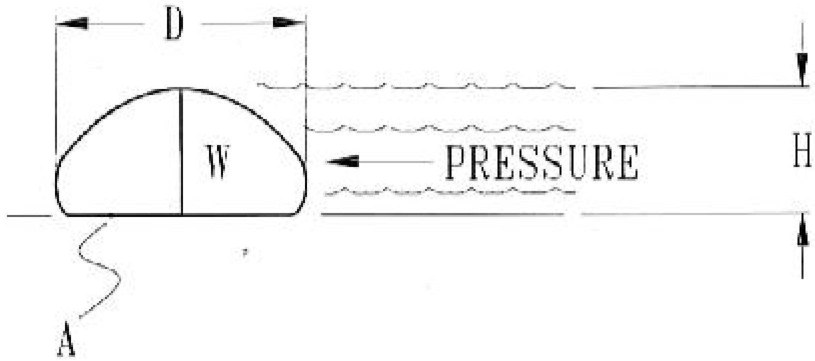


As water pressure builds on one side of the AquaDam®, the pressure displaces the water in the inner tubes. However, because the inner tubes are unable to move, the AquaDam® assumes a position of equilibrium and behaves as a solid dam.



In order to move or tip a filled AquaDam®, the maximum recommended working depth would have to be exceeded. Too much water pressure against the side may cause the entire AquaDam® to slide or tip sideways, depending on the nature of the surface and friction factor it is placed on. It would be technically impossible for one tube to roll completely over another in a filled AquaDam.





In order for an AquaDam® to move as a result of the pressure exerted on one side, it must slide across the surface on which it rests. In order to tip, the water pressure must lift the first inner tube up and over the second. The following calculations show the AquaDams® resistance to tipping:

Assumptions:
To facilitate the calculations, we will assume that the inner tubes are generally rectangular when filled. As the worst case scenario, we will assume that the water level on one side has reached the top of the AquaDams®.

P = pressure
h = water depth
D = width of AquaDam®
I == length of AquaDam®
p = mass density of water
g = gravitational acceleration
Y = specific weight of water
F= force exerted on the face of the AquaDam® due to pressure (P)
A = area of the side face of the AquaDam®
W = weight of water in the inner tube
V = volume of the inner tube
P = pgh = yh

$$P_{avg} = \gamma(h/2)$$
$$A = hl$$
$$F = PA = P_{avg}A$$
$$W = \gamma V$$

The force exerted on the side of the AquaDam® is then:

$$F = \gamma \frac{h}{2} hl$$

Having determined the force on the side of the AquaDam®, we can evaluate the tendency of the AquaDam® to tip. We assume point A as the pivot point and sum moments about this point. The moment created by each force, is a measure of how much the force contributes to rotating the first column of water around point A.

$$\sum M_A = W\frac{1}{2}D - F\frac{h}{3} = 0$$

OR

$$\sum M_A = \rho h \frac{D}{2} l \frac{D}{2} - \rho \frac{h^2}{2} l \frac{h}{3} = 0$$

Simplifying the expression we see that the stability of the AquaDam® is dependant on the relationship between its width (D) and the depth of water it must resist: ***D=(.82)h***

The relationship above indicates the minimum width of the AquaDam® to prevent it from tipping when resisting water with a depth (h) equal to the height of the AquaDam® itself. The design height for the AquaDam® to prevent tipping would be described as: ***D>(.82)h***

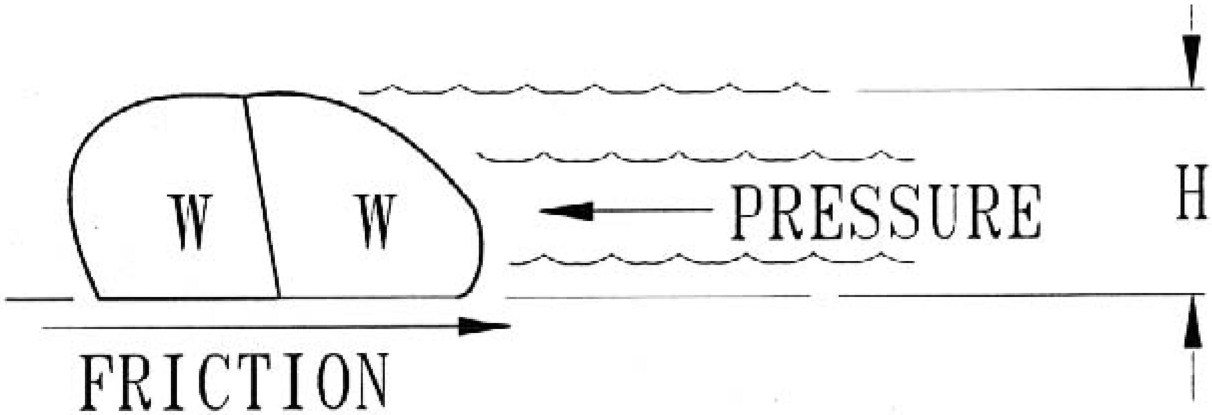
In order to quantify the stability of the AquaDam® we substitute the actual dimensions of the standard AquaDam® for D and h into the equation above. The results are expressed in terms of a safety factor. The safety factor indicates how many times greater the water pressure or water depth must be in order to roll the AquaDam®. Based on the current AquaDam® designs, the safety factor against tipping when the water levels are to the top of the AquaDam® are as follows:

INFLATED HEIGHT (in inches)	INFLATED WIDTH (in inches)	SAFETY FACTOR AGAINST TIPPING
12	24	2.44
24	46	2.34
36	68	2.30
48	120	3.48
72	186	3.15
84	282	4.12

If the recommended maximum water depth is maintained, the safety factor against tipping is improved. The following table illustrates the improvement when recommended water depths are observed:

INFLATED HEIGHT (in inches)	INFLATED WIDTH (in inches)	RECOMMENDED MAXIMUM DEPTH	SAFETY FACTOR AGAINST TIPPING
12	24	8	3.65
24	46	18	3.11
36	68	28	2.96
48	120	36	4.06
72	186	54	4.20
84	282	72	4.78

The second method for moving the AquaDam® is to slide the entire dam. The resistance to sliding is provided by the friction between the ground and the structure. Although any type of barrier could slide along the ground if the pushing force were great enough, we will present the calculations for sliding the AquaDam® in order to quantify its tendency to slide.



In addition to the variables already defined we add:
μ=coefficient of friction between AquaDam® and its supporting surface
f=friction force
N=normal force (equivalent to weight)

Assumptions:
We are assuming that the supporting surface is smooth and flat. Any deviation from a smooth surface will add greater opposition to sliding. Again, we assume that the inner tubes are generally rectangular to facilitate the calculations: ***f=μN=μW***

$$\sum F_x = \mu W - F = 0$$

or

$$\sum F_x = 2(\gamma \frac{D}{2} h l)\mu - \gamma \frac{h}{2} h l = 0$$

Deriving a term for the coefficient of friction yields: $\mu = \frac{h}{2D}$

*For current AquaDam® designs, the coefficient of friction (**μ**) that will allow sliding are as follows:*

INFLATED HEIGHT (in inches)	INFLATED WIDTH (in inches)	WHEN WATER LEVEL = AQUADAM HEIGHT
12	24	.25
24	46	.26
36	68	.26
48	120	.2
72	186	.19
84	282	.15

The coefficient of friction that will allow sliding if the recommended maximum water depths are observed:

INFLATED HEIGHT (in inches)	INFLATED WIDTH (in inches)	RECOMMENDED MAXIMUM DEPTH (in inches)	WHEN RECOMMENDED WATER LEVELS ARE USED
12	24	8	.11
24	46	18	.15
36	68	28	.16
48	120	36	.11
72	186	54	.11
84	282	72	.11

Coefficients of friction ranging from .10 - .20 indicate that the surface may be quite slippery. For example, the coefficient of friction between two pieces of greased or oiled steel is .10 - .20. Again we have assumed that the surface under the AquaDam® will be comparatively rough and will pose even greater opposition to sliding than indicated in the calculations above. The principles used to create the AquaDam® are simple, yet effective. The stable non-rolling wall of water conforms to the surface beneath it, creating a tight seal. The AquaDam® remain stationary even if water levels reach the maximum recommended water containment depth. AquaDams® provide a lightweight, reusable and ecologically safe method of temporary water control.