Capturing River Floods Offshore with Textiles

Mark E. Capron, PE, and James R. Stewart, PhD, September 10, 2009

Flood issues

People are running out of useable fresh water. Part of the cause is pollution of existing supplies. Part is increased human population. Part is the effect of Climate Change. Per a 2007 study by the Environment California Research and Policy Center, and numerous other climate studies, extreme 24-hour storm events (floods) are increasing. Also, a National Science Foundation study of 925 rivers found the total runoff has declined significantly in most rivers. The decline in total flow is also expected to increase with increasing greenhouse gas emissions. California will have less winter precipitation stored as snow. India and China will have seasonally dry rivers after Himalayan glaciers melt. Capturing floods with textiles is a crucial Climate Change adaptation.

Traditionally, dams have been employed to control floods and store water for use during droughts. The sites available for traditional dams have decreased. People have become more aware of the environmental and social impacts of flooding canyons. Water engineers have refocused their attention on groundwater storage. However, it is extremely difficult to store a flood in the ground without first capturing it. Otherwise, the water is gone before the relatively slow processes of injection or percolation can store a significant quantity in the ground.

The problem is one of flow rate. For example, the Los Angeles River is a concrete lined channel. The 100-year flood on the Los Angeles River is 175,000 cubic feet per second (5,000 m^3/sec, 14,000 acre-feet per hour). The existing groundwater recharge basins along the route can hold about 1,000 acre-feet (1.2 million m^3) or 4 minutes of flood flow. This means Los Angeles captures less than 1% of the river runoff during a large 24-hour storm.

In all the situations listed below, the ideal is for the fresh water to remain captured in the textile structure for a relatively short time, a month or three. It should be conveyed from the textile structure into ground water storage or some beneficial use within the month. The more time it can be empty, the more opportunities for capturing a flood. While it is empty, it is also useful to be out of the way. That way, the land space covered by a full textile structure is available for agriculture between floods.

Particularly cost effective textile structures are obtained with strong porous textiles arranged as tubes with thin impervious liners. The porous textile tubes, such as the Miratec GeoTube and the Flint Industries TitanTube, can be filled about 6-foot (2 m) high with water for any width of tube. If the tube is supported by earth or other structures, the water can be deeper. Note that a single unsupported tube rolls relatively easily, if filled on a slope. The tube stress is similar for a tube 100 feet thick full of fresh water floating in sea water. It can be inexpensively lined with an impervious liner to hold water.

Over the last decade or two, plastic manufacturers have advanced the strength, durability, and cost effectiveness of textiles. Those advances can be exploited to capture floods in innovative and cost effective ways.

Capturing River Floods Offshore

Where the river enters the sea the lower density fresh water will spread out over the higher density seawater. Figure 1 is an aerial photo of a river delta on which are drawn several free-floating watercurtains (not to scale). The circular watercurtain consists of a textile with an impervious membrane. The watercurtain holds fresh water while floating in the sea. In this free-floating version, flood waters are carrying the watercurtains out to sea.

Figure 1 – Aerial view of offshore river delta flood capture

Prior to capturing fresh water, the watercurtain had been prepositioned on the sea floor, as in Figure 2. It is prepositioned in a circle in plan view, held close to the bottom to minimize storm wave forces. It is held down with latching devices, which may be triggered by electrical (hard wire) or sonar signal. When the latches are triggered to release, its floats will pull the watercurtain up and it will capture a circular "core" of fresh water, as shown in Figure 3.

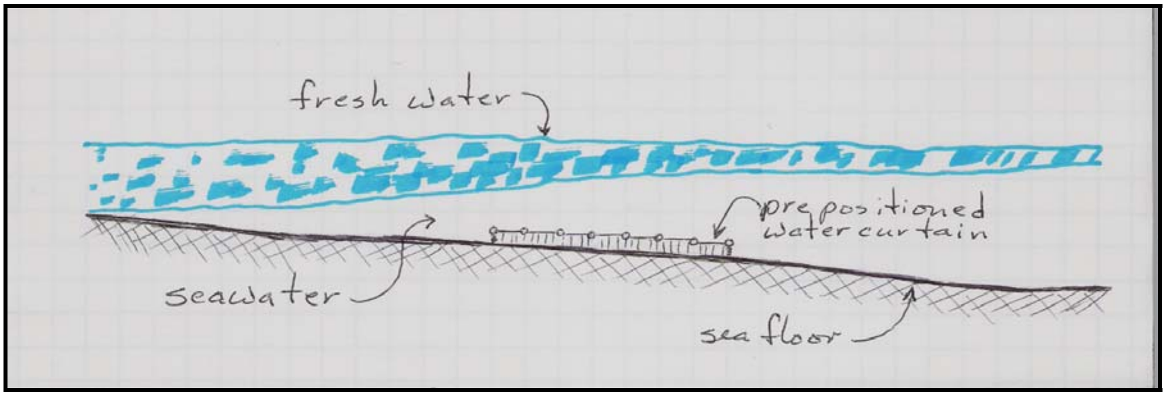

Figure 2 – Side view of prepositioned watercurtain

The watercurtain could be allowed to drift in order to minimize forces that might spill the fresh water or create turbulence that would mix the salt water with the fresh water in the open-to-the-bottom area inside the watercurtain. As it is pushed out to sea by the flood waters, Figure 3, the fresh water layer outside the watercurtain becomes thinner. Figure 4 shows the thicker fresh water inside the watercurtain floats with slight freeboard above the predominantly saltwater outside the watercurtain. The result is horizontal radial forces that tend to keep the watercurtain's plan view shape as a circle.

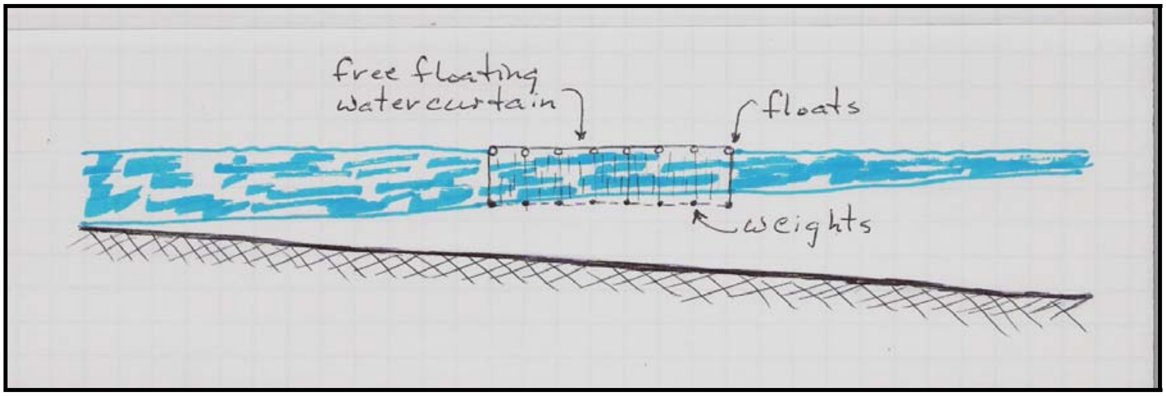

Figure 3 – Side view of free floating watercurtain

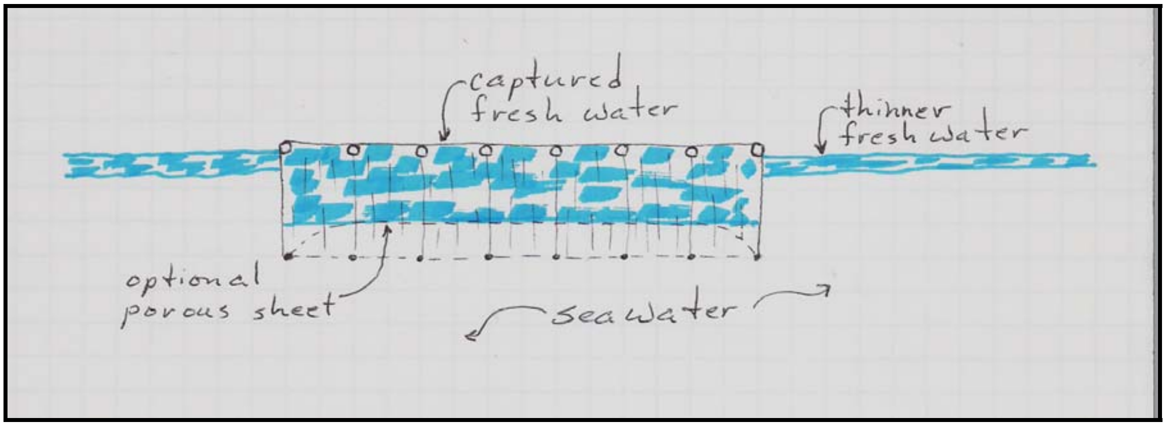

Figure 4 – Close-up side view of water curtain after fresh water has spread over ocean surface

Many variables affect how quickly the salt water will mix with the fresh water, but it will be much slower than without the watercurtain. Before substantial mixing occurs, the fresh water must be collected. Vessels would approach the watercurtain, as in Figure 5, and use a floating suction system (not shown) that pulls from the layer of fresh water within the watercurtain. The fresh water can be either pumped to shore or stored in textile bladders (described as "watertubes" elsewhere on this website). As the vessels pump, they may constrict the watercurtain (reduce its circumference) to maintain or even increase the thickness of the fresh water. After harvesting the fresh water, the watercurtain is repositioned on the sea floor in preparation for the next flood.

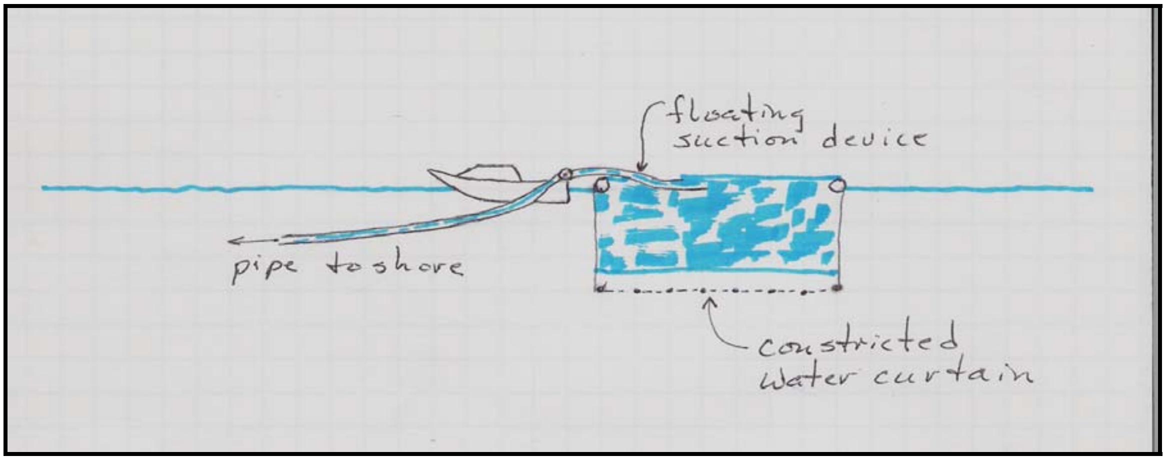

Figure 5 – Removing the fresh water

After trials with the simple water curtain, enhancements that prevent or delay salt and fresh water mixing may prove cost effective. One enhancement would be to place a "liquid" that does not mix with water, but is of intermediate density at the interface between the fresh and salt water. Such a "liquid" is easily approximated using containers that are filled half with salt water and half with fresh water with the proportion adjusted to compensate for the density of the container material. Another approach would be to add many small vertical curtains that float at the interface. The small curtains would have the effect of preventing flow, and therefore turbulence, along the interface. Both of these mix-preventing enhancements allow sediment to drop out of the fresh water, unlike an impervious sheet. A third approach is shown in Figure 4, a porous sheet of intermediate density. The porosity is sufficient to allow the initial vertical transit of the watercurtain from its prepositioned location.

A typical watercurtain may be 660 feet (200 m) in diameter. A watercurtain with a vertical extent of 16 feet (5 m) may capture and yield a core of fresh water that is 10 feet (3 m) thick. That could be as much as 80 acre-feet (100,000m^3) of stormwater. By operating and maintaining 400 watercurtains, each making six captures per year, the total annual capture would approach 200,000 acre-feet (600 million m^3).