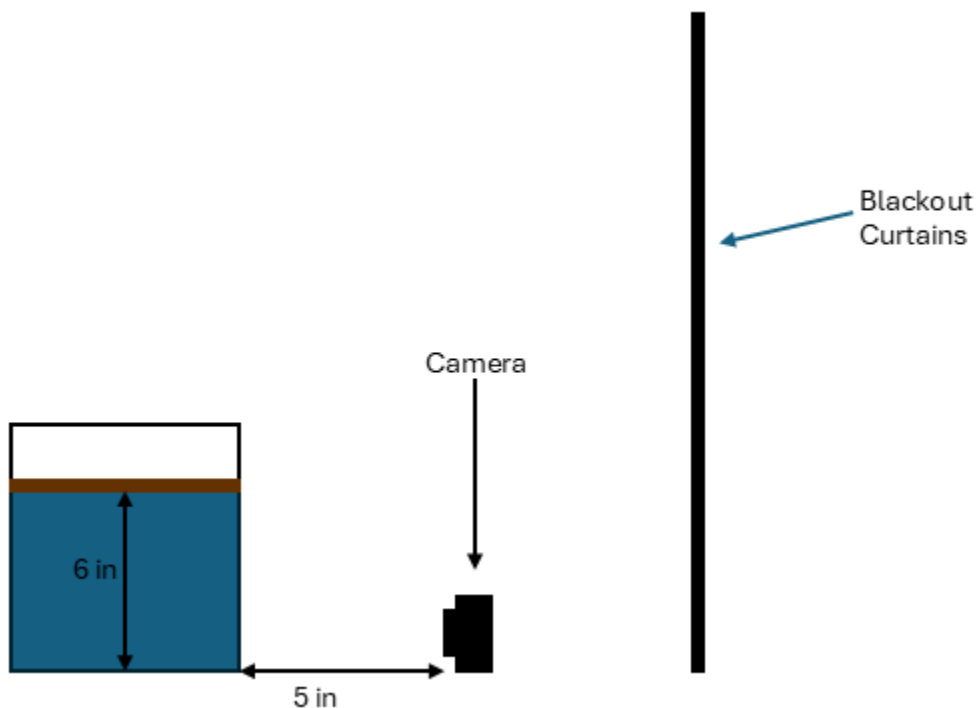


The visual shows soil floating on top of water falling through the water creating currents as less dense particles and pulled down then float back towards the surface. The goal of this visual is to see a simplified version of some of the physics that could be occurring from river erosion or flash flooding where dirt is transported in water currents. Our original plan for this visual was to photograph rainwater infiltration into soil, but this proved too difficult to light in a way that the fluid was visible and there wasn't large amounts of reflection off the sides of the container.

The final set up for the visual ended up quite simple. A fish tank was placed on the ground with 6 inches of water. Behind the fish tank was a window to provide light through the water. Soil was very lightly distributed across the top of the water's surface. The camera was placed on the ground 5 inches from the tank. Blackout curtains were then raised behind the camera to prevent glare/visible reflection off the front of the fish tank.



The soil particles are experiencing three forces as they move around within the water. The first and second forces are gravity and buoyancy. These two forces are primarily dictating whether or not a specific particle floats or sinks and this balance is determined by density of the particle. These forces will not be calculated since for the phenomena being shown all that matters is that some sink and others float.

The last force being experienced by the particles is the drag forces being produced by the water moving around the particles as they move within the water. The effects of these forces

will be shown by calculating the particle Reynolds number around the heavier particles as they are falling, and the lighter particles as they float back to the surface. The particle Reynolds number is calculated as:

$$Re_p = \frac{d \rho V_p}{\mu}$$

Where d is particle diameter, μ is the water viscosity, ρ is the fluid density, and V_p is the particle velocity. The particle diameters will be estimated at an average of 0.016 ft, and the smaller floating particles will be estimated at an average of 0.008 ft. The density of the water at room temp is roughly 62.4 lb/ft³. The dynamic viscosity of water at room temperature is 2.05*10⁻⁵ lb * sec/ft². The velocities for each particle will be estimated by tracking the distance they travel over time in the video. The larger particles fall through the 6 inches of water in approximately 1 sec giving a velocity of 0.5 ft/s, and the smaller particles float up the 6 inches of water in approximately 3 sec giving a velocity of 0.17 ft/s. Using these values we can calculate the respective Reynolds numbers:

$$Re_{pH} = \frac{0.016 \text{ ft} * 62.4 \text{ lb/ft}^3 * 0.5 \text{ ft/s}}{2.05 * 10^{-5} \text{ lb*sec/ft}^2}$$

$$Re_{pL} = \frac{0.008 \text{ ft} * 62.4 \text{ lb/ft}^3 * 0.17 \text{ ft/s}}{2.05 * 10^{-5} \text{ lb*sec/ft}^2}$$

This gives a Reynolds number of 24350 for the heavy particles and a Reynolds number of 4140 for the lighter particles. This indicates that both sets of particles are creating turbulent flows around them, but the much higher number of the heavy particles indicates that they are creating a large turbulent flow around the particles. This lines up with what we see in the video as the heavy particles create a turbulent enough wake to drag the lighter particles down with them. The lower Reynolds number for the lighter particles is visible since they don't create the large wake seen with the heavy particles and instead each particle moves independently.

We used a differentiated boundary technique for this visualization. The various particles in the soil are all non transparent making them stand out in the clear water that they were in. The video started 40 seconds after the addition of soil to the tank to allow for the flows to begin without the video becoming too long. After the end of the video the water quickly became too cloudy for the flows to continue to be visible. We used natural lighting through a window behind the fish tank to light the shot. The visualization was taken on a bright day, but the lighting through the window was indirect as the sun was not directly visible through the fish tank. This bright lighting was essential for being able to see through the water in the tank fully and allow for the flow throughout the whole tank to be visible.

FOV	12 in x 6 in
Distance	5 in
Lens Specs	8.8mm - 36.8 mm

Camera Type	Canon Powershot G7X mk2
Image Size Original	1920 x 1080
Image Size Edited	1920 x 1080
Frame Rate Original	29.97 fps
Frame Rate Edited	25 fps

Image processing was light with the only changes being a title section being added and the color grading being slightly warmed up.

The video shows various particles that make up a soil mixture sinking through water, pulling less dense particles down with them, which then slowly float back towards the surface. This effect creates small scale circulatory currents within the water. The ability to see the physics is the strongest part of this visual as they are very clearly visible, and the lack of other things happening in the video allows the flow to be the full focus. The main question I have about this image is any suggestions to improve the artistic element of the visual. While I really like it from a physics perspective I feel that there is significant room for improvement on the artistic side. One suggestion I've gotten to improve this would be colored lighting which I do believe would help. One big way to develop the idea of soil transport in water would be to induce a flow throughout the entire water stream, although this would make capturing the physics well more difficult.

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