

Op:ed - Derna, tailings and castles built on sand

Could a simple syphoning technique deployed in mine tailings dams have been used to protect Derna?



Underground Mining > Tailings

Comments

James Cormier-Chisholm,
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The rain exposes the drenched streets, the cheating contractor, and the failed state.

It washes everything, bird wings and cats' fur.

Reminds the poor of their fragile roofs and ragged clothes.

It awakens the valleys, shakes off their yawning dust and dry crusts.

The rain a sign of goodness, a promise of help, an alarm bell.

"An Alarm Bell," Libyan Poet Mustafa al-Trabels. Poem written days before Dena City Flood, poet died in Derna City Flood^[1]

This article presents a gravity siphon method to help prevent dam overtopping, which was developed and tested by the author on a tailings dam under emergency flood risk of over topping flood conditions 30 years ago, with 100 meters of snowpack induced flood waters to deal with as the dominant condition.

This gravity siphon method is applicable to any dam at risk of overtopping, especially under volatile climate conditions, and even could have been applicable in the tragic Derna City flood in Libya earlier this month that killed 4,000 and left 9,000 missing.

What is the need for this method? We need more flexible methods to quickly dewater dam structures.

The Derna dams' failures are an example of over-reliance on just one dewatering method behind dams under major flood conditions.

Storm Daniel peaked in northeastern Libya on September 10 with winds of 70-80 km/h. The storm caused communication disruptions due to fallen electricity towers and trees. Torrential rains of 150-240 mm led to flash floods in several cities, including Al-Bayda, which set a new Libyan rainfall record with a daily rate of 414.1 mm (See Fig. 1, main impact area of flood).

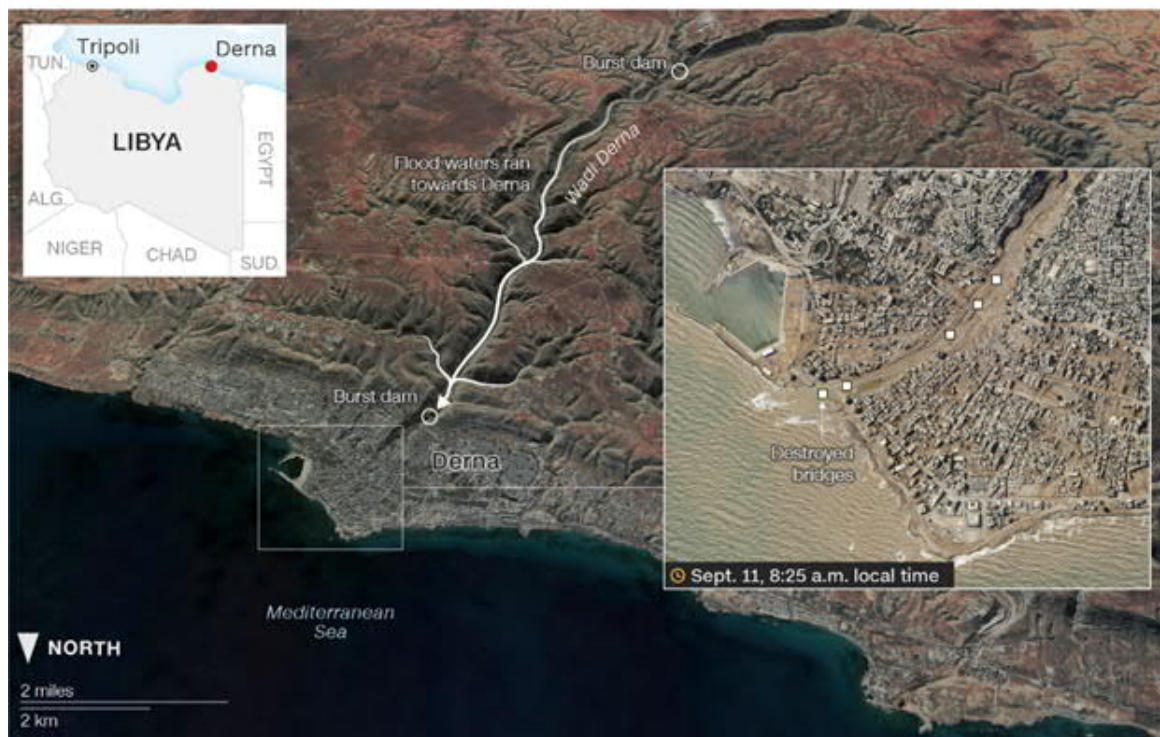


Figure 1 City of Derna on September 11, after flood kills 4000 People. Source CNN.

This 1 in 600-year weather event appears to be due to increasing weather volatility - a result of climate change - that overtopped two dams with a rain event. Overtopping accounts for over 30% of both concrete and earth dam failures.

The Abu Mansour Dams (74 meters high, 14km from City of Derna) and Al-Bilad Dam, just outside the City of Derna, Libya, had reservoir capacities of 22.5 and 1.5 million cubic meters respectively, and burst after Storm Daniel dumped 100mm of rain on Derna area on September 10 and 11 (**See Figure 2 & 3**).

The resulting floodwaters rose to heights of 3-7 meters, rolling over and carrying off people, rock, trees, buildings, and silt. The flood removed 20% of Derna City's buildings and infrastructure. The flood swept entire neighbourhoods out into the Mediterranean Sea.

Why did the dams fail? We can only speculate, as there is nothing left of the dams to detail evidence. Perhaps a survivor will stumble forth at some point to add details. There were attempts several years ago for dam maintenance, and calls for immediate maintenance to the two structures, located just uphill from the coastal city of Derna. But successive governments in the chaos-stricken North African nation did not react.

Pre-flood satellite images show both Derna dams had spiral drains, were very poorly maintained by all accounts, plants were growing on the dams, and likely would have been immediately blocked by entrained debris from the flash flood waters tumbling down Wadi Darnah. From satellite images, both Derna dams had only one method to dewater, spiral drains, prone to blockage, to dewater behind these dams (**See Fig. 2 & 3**).



Figure 2 Upper Al-Bilad Dam failed first September 10 along Wadi Darnah. Dam had a spiral riser pipe, with no emergency spillway. Author's figure. Google Earth



Figure 3 Abu Mansour Dam, downstream of the Al-Bilad Dam failed September 10. Dam had a spiral riser pipe, with no emergency spillway. Author's figure. Source: Google Earth

Dams can have a spiral drainpipe, or a riser drain tower to drain water and prevent overtopping. The two Derna Dams had such towers, spiral drains (**See Figure's 2 & 3**). Spiral drain towers can get blocked by flash flood debris. This can cause a dam overtopping and subsequent failure. Such riser drainage towers drain through a earth dam. Internal erosion of a dam from "piping" is another source of failure.

Other dam designs have an emergency spillway built out of concrete or cut through rock. Think of that as two chances to successfully dewater behind a dam. The Derna Dams did not have an emergency spillway built out of concrete or cut through foundation rock (**See Figure 4, Emergency spillway**). A spillway can lower the water level and reduce the risk of failure. If the drain is blocked (*...or someone forgets to open the lower gate valve built into these risers drain towers outlet end*), the water will rise, the dams can overtop, and then dams can fail quickly, in hours. As noted, spillways are built either through rock, or with concrete, and can take considerable time to build.



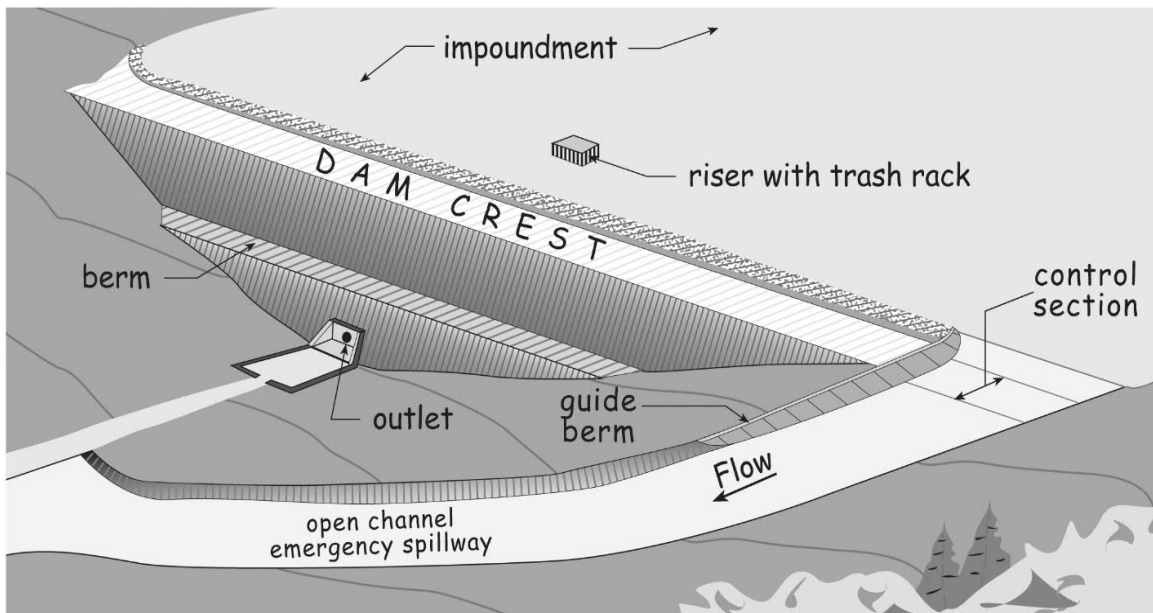


Figure 4 Ideally, current dams should have both an emergency spillway and a drainage riser with trash rack. Source: Association of State Dam Safety Officers, USA

At an emergency level flood water height, a spillway activates. Spillways activate only a few meters below the overtopping height of a dam. This a last resort method for dewatering behind a dam under rain flood conditions. Dam failures in the past can happen at spillway height of water as there is a high-water pressure to be held back by a dam structure, and earth dams are more prone to fail under spillway water level conditions. If the spillway activates, you better not been in a building underneath the spillway in a flood plain, as even spillway waters can cause limited flooding.

In the case of the City of Derna, it was very apparent from a review of satellite imagery that many buildings, and a road, were built on the floodplain underneath these dams. Ideally, one should not place occupied buildings downstream of a dam, a city planning feature lacking in war-torn and chaotic Libya.

This article introduces a third method for dam dewatering that doesn't require maximum water height, doesn't compromise the dam's core structure, and uses HDPE poly pipe. HDPE poly pipes can be arranged in parallel for redundancy, ensuring continuous drainage even if one pipe is blocked. This simple, yet effective method can be implemented under emergency conditions or pre-established for readiness as a method. This method was developed and successfully used by the author thirty years ago to repair a tailings dam under rising flood conditions.



Gravity Siphon Close and Open Pipe (GSCOP)

In the event of an earth dam emergency or to take water pressure seasonally off an existing dam, the following is a method, GSCOP, that the author applied during an active earth failure event that worked for him.

It is a method to more easily start a gravity siphon to dewater behind a earth dam, and below spillway elevation to remove water behind a earth dam (...or any water retaining dam). It can be applied whether or not a dam has a spillway, or other dewatering method. High density polyethylene (HDPE) is a thermoplastic polymer produced from ethylene, and is the material used to make poly pipe.

This method fills a larger poly pipe, or several smaller pipes in parallel, to start a gravity siphon of water more easily. Disclaimer: this method described here is a rough approximation: it is not intended to be relied upon by any person for accuracy as it is very high level and conceptual. A civil construction company or mining company can use a qualified engineer(s) to develop their own procedure suitable to meet local dam site conditions from this rough outline of a procedure.

Before the wet season, set up large poly pipe(s) over the dam or dams in question. Install a large poly pipe from the dam upstream reservoir area to a lower point downstream of the dam. It's advisable to install multiple parallel pipes for efficiency, and as a redundancy against pipe blockage from debris. Two closed gate valves are installed at the uppermost and lowermost elevations of the poly pipe.

For a large reservoir and dams, use one to a parallel series of large diameter parallel poly pipes, for a smaller dam, smaller poly pipes diameters, all sized according to qualified engineer calculations for dewatering of potential flood waters. The input end of the earth pipe should be free of obstructions and placed where it won't suck up debris that can block it. The output end of the pipe(s) should have large rip rap installed to disperse the energy of water output to prevent water scour. The pipe can be draped over an existing dam, or along the sides of the dam, but at a higher elevation than the dam crest.

At the highest point of the pipe (**See "crest" in Figure 5, that is the crest of the pipe, the pipe's highest elevation going over the dam**), tap (drill) two holes into the HDPE pipe(s). One hole will serve as a water input hole from a small Honda pump, and the other hole is an air outlet. Secure the end of the large poly pipe to trust blocks at lowest elevation using suitable cabling to prevent movement from potential water hammer as water initially moves by gravity siphon down to the lower elevation output poly pipe (**See Figure 6**). Use a Honda 4" trash pump to fill the large poly pipe with water slowly from this crested elevation of pipe that goes over the dam (use pond water from the reservoir, or water trucked in from



elsewhere). This large pipe generally will take several hours to fill with this method. Once the pipe is full, seal the hole used by the trash pump and the air hole at the crest of the pipe that goes over the dam. Now, you have a filled pipe(s) ready for use as a dewatering method during a flood event.

The gate valves best have an automatic' motorised function to open and close the gate valves on the underwater upstream poly pipe end and lower output end. However, if pressed, this can be gate valve opening can be done manually. In the author's tailings earth dam emergency, he used two men to open two manual gate valves simultaneously (...at the time he coordinated the men's timing of gate valve opening slowly with walkie talkies, nowadays, use cell phones). The man on the input end of the valve gate in the author's 30 years ago case, had to ride an excavator bucket to open the input valve, which is a riskier proposition than an automated valve opening. However, as the alternative was a complete dam failure at the time, the procedure was successfully carried out manually. The earth dam (a tailings dam) was saved, and repaired.

Open both valves slowly and simultaneously - to prevent water hammer and potential pipe movement at lower elevations - to start a gravity siphon and to dewater a dam reservoir. If dam repairs are needed, they can be carried out once water is removed below an elevation that may allow repairs of the earth or concrete dam, or to prevent excessive water pressures on an existing dam until the rain event and rise in waters behind the dam has passed.

Small trash pump fills large poly pipe with water using tap hole and air outlet *at pipe crest*.

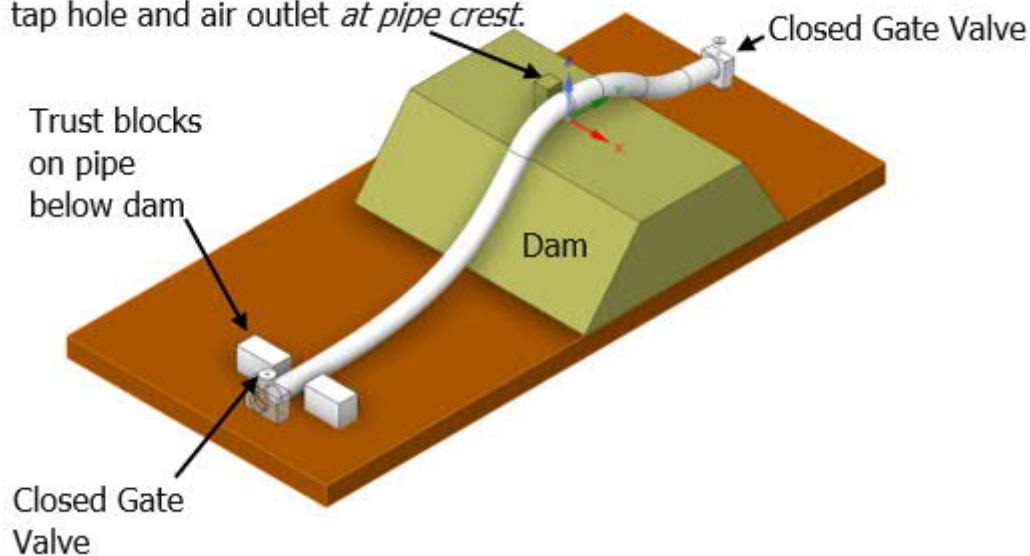


Figure 5 Poly pipe can be set up before the wet season. Crest of pipe can have two tap holes bored (trash pump 4" water input, air outlet holes). Author's figure.



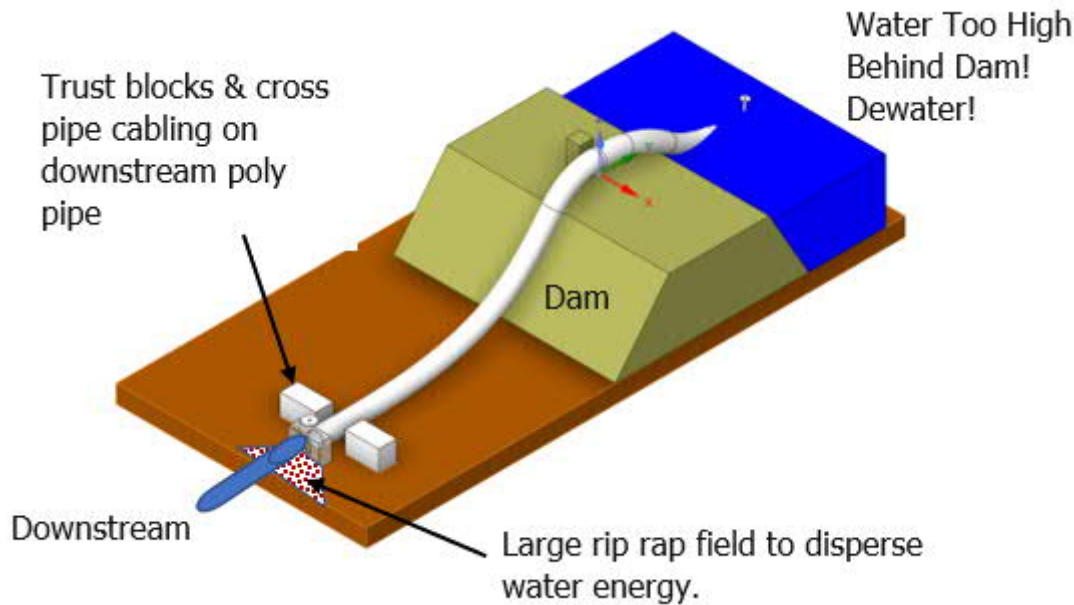


Figure 6 Wet season comes, both gate valves now open. Dewatering by gravity siphoning

Source: Author's figure.

As noted, in case of an emergency like an impending flood, this setup can be used to siphon flood waters from the reservoir upstream end, past the dam structure, to the lower downstream output end, in a controlled manner. You can set up more than one pipe at different elevations on the upstream reservoir end depending on needs, keeping water pressure lower at existing dams. This procedure allowed repair of a large crack in an earth dam\tailings dam 30 years ago under flood conditions from rapidly melting snowpack. However, best to have this dewatering method set up before a potential flood.

Conclusion

Climate change engineering for extreme weather events now requires additional measures for dam safety, given recent September tragic event of the City of Derna two dam collapses. This article shows this dewatering technique, Gravity Siphon Close and Open Pipe (GSCOP), a method to start a gravity water siphon to keep flood waters lower behind a dam, and at less risk of overtopping dams.





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