# NO DRAIN TO PULL? WELL THAT SUCKS!
# PENNSYLVANIA'S EMERGENCY RESPONSE TEAMS MAY BE ABLE TO HELP!

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## Introduction

In past practices, construction of smaller dams, whether farm ponds, historic ice ponds, or strictly aesthetic amenities constructed prior to the mid 1970s, rarely incorporated a low level or drawdown conduit. Additionally, aging facilities with a drawdown system may have operability issues stemming from rusted or stuck gates, broken controls, or deteriorated conduits. Therefore, if a dam emergency were to occur at one of these facilities, lowering of the impoundment level to aid in preserving the structure and averting a potential disaster could be very involved and costly.

Noting the lack of a drawdown conduit as a significant concern, the PADEP Division of Dam Safety began taking steps to secure compact mobile siphoning setups in 2002. These setups are comprised of 6-inch diameter schedule 40 pvc pipe, assorted fittings and connectors, a gasoline-powered trash-pump, and hand tools. All of these supplies are stored within an enclosed cargo trailer, which can be easily connected to a truck and moved to the site of an emergency.

## Siphon Theory

A siphon, despite its apparent complicated theory, is a simple yet powerful tool proven very useful for moving fluids over small elevation gradients. Siphons are commonly used to move water, gasoline, oil, and liquid metals. Siphons range in size and variability from small compact systems such as the common toilet bowl to large-scale water supply systems and

emergency spillways for dams. However, in all applications the workings of the siphon are the same.

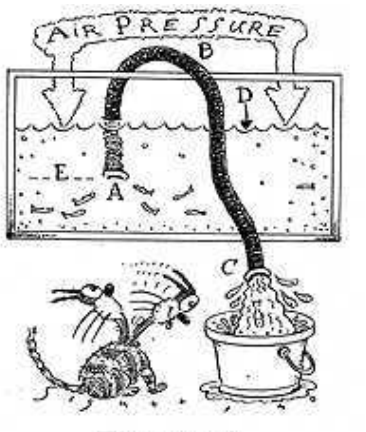

Figure 1

The crest height at which a siphon will successfully operate (point B in Figure 1) is limited by the effective atmospheric pressure and the fluid density of the reservoir. Theoretically, for water at standard atmospheric pressure in a vacuum, the maximum crest or "lift" height obtained is about 33 feet. A reservoir filled with mercury would limit this crest height to about 30 inches. However, in "real world" applications water typically begins to vaporize at lift heights approaching 20 feet, and for every 1,000 feet in elevation above sea level, the reduction in atmospheric pressure results in a decrease to the lift height of about 1 foot. This combined with the fact that a perfect vacuum cannot be obtained in field applications and minor air leaks will undoubtedly exist, the typical lift height is usually limited to about 15 feet.

## Siphon Equipment

In 2002, the Division of Dam Safety began investigating the use of temporary siphon setups to be implemented in certain situations to aid in averting dam emergencies. Then, beginning in 2003, a decision was made to purchase equipment for two mobile siphon units, with three more completed in 2005, and an expected addition of two more this year. Each trailer is supplied with enough material to construct up to 250-linear feet of 6-inch siphon. Currently, four of these trailers are distributed across the State to Regional Office Emergency Response Teams, with one being maintained by Dam Safety staff in Harrisburg.

The following is a list of equipment and supplies:

- 6-foot by 12-foot cargo utility trailer
- 3.5 horsepower 2-inch diameter gasoline powered trash pump

- 6-inch diameter Schedule 40 pvc pipe (cut to 10-foot lengths)
- rubber Fernco© fittings for 6-inch diameter pipe
- assorted 6-inch diameter fittings and elbows
- battery powered cordless tool kit (drill, saw, etc.)
- assorted hand tools (pipe wrench, hammer, pliers, etc.)
- pad locks for trailers
- pvc cleaner and glue
- gas can and oil for trash pump
- personal protective equipment (gloves, goggles, etc.)
- reinforcing bars / steel stakes for anchoring siphon
- vehicle to pull trailer and associated hitching equipment

The Commonwealth was able to purchase this equipment at a cost of roughly $6,500 per trailer (not including the tow vehicle). Monies for these purchases were used from Federal Dam Safety Grants and the State's Dam Safety and Encroachments Fund.

## Initial Preparations

In order to maximize the efficiency of setup, a great deal of initial prep work can be performed prior to placing the siphon supplies into operation. Since pvc glue takes time to dry, the use of glue should be minimized on site. Additionally, these supplies are intended to be re-usable, so coupling and gluing together long straight sections of pipe will result in wasted materials when the pipe is disassembled and needs to be cut. When using pvc glue on elbows, caps, or tees, a small straight section of pipe should be incorporated into each end to allow for the use of rubber Fernco© fittings for quick field connections. Also, self-tapping screws can be placed through the coupler or elbow and into the pipe to aid in preventing the pipe from torquing and breaking the glue bond. Air leaks can be prevented by placing pvc glue over the screw head. It is also

advantageous to prepare a few “over the crest” sections with fill tees and a valve or cleanout plug.

Initial preparations should not stop with the pvc siphon pipe itself. If the trash pump is brand new, it may take some time to get it operational and running smoothly, and the cordless tool kit batteries will need charged. Having these items prepared prior to arriving at the site can save valuable time during an emergency situation.

## Site Considerations

These small mobile siphon systems are limited in operation and may not be the appropriate means for obtaining the desired objective. Before heading to a dam site with the intent to install these siphons, a brief review of the site characteristics should be conducted to answer the following five questions:

***What Is the Intended Final Result of the Dam and Purpose of the Siphon?***

Answering this question will provide justification for using a siphon as an emergency operation. The key to determining if a dam emergency exists is whether the dam in question poses a downstream safety hazard. If a hazard exists, siphons can be used to accomplish two main goals during an emergency. Depending on the intended final result of the dam, lowering the pool level and performing an emergency repair to damaged or inoperable structures, or lowering the pool level to perform an emergency breach of the dam’s embankment, are the two main options. The setup location of the siphons, amount of siphons, and coordination of other activities should be considered. If the intent is to repair the dam, then the proper materials and equipment must be present to perform the repair. If the impoundment is to be drained and the dam breached, then the setup location of the siphons should be evaluated to prevent problems during the breach.

***What is the Estimated Drainage Area to the Dam?***

The use of 6-inch diameter siphons on a dam with a contributory drainage area exceeding a couple square miles will not be very useful for draining or lowering the pool level. However, if the intent of these siphons is to relieve or reduce spillway flows through a

damaged area, then siphons may be considered on large drainage areas. Considering the size of the watershed will aid in prescribing the number of siphons needed for the intended result. The Commonwealth has found that these siphons are most useful for watersheds under one square mile during normal flow conditions.

***What is the Height of the Dam?***

The height of the dam plays a major part in determining whether siphons are a feasible method to avert a potential emergency. Constructing three siphons on a 50-foot high dam will require more materials than constructing five siphons on a 20-foot high dam. Additional materials may need to be located and sent to the site. Since the weight of the water within a long run of siphon pipe on a slope can break the fittings, the downstream leg of the siphon should be anchored to the face of the dam for a run exceeding 25-feet. Placement of a siphon on a very steep slope will require more anchoring.

***Where is the Normal Pool Level Relative to the Top of Dam?***

It is clear from the siphon theory presented earlier, the maximum lift height is usually limited to between 15 and 20 feet. Therefore, if the normal pool level is set 10-feet below the top of dam elevation, a siphon setup over the dam crest would be limited to lowering the pool up to 10 feet. However, in some situations the crest of the siphon could be placed closer to the pool level by setting the siphon through the spillway section, which will increase its draw depth.

***Can the Utility Trailer and Equipment Gain Reasonable Access to the Dam?***

If a pickup truck and utility trailer cannot get close to the dam, preferably on the dam, then the time it will take to setup and render a siphon operable may not be sufficient, and another means of handling this emergency should be considered.

## Siphon Setup

Once it is determined that a siphon will be useful for a particular situation, then begins the daunting task of getting the equipment to the dam site and setting up the siphon. The 6-inch diameter pvc pipe was mainly selected for ease of quick construction without the need for

large lifting equipment. Ten-foot sections of 6-inch pvc pipe are about the maximum size that one person can safely handle. A well-trained two-man crew can assemble, prime, and have an operational siphon on a 20-foot high dam in about one hour or less.

The siphon(s) should be located where the minimum “lift” height from the pool level exists, while taking into account where the best location of the discharge end should be. The outlet should be placed preferably within a downstream spillway channel, plunge pool, or other protected area to prevent scour and erosion. If possible, the outlet end of the siphon should be submerged to prevent air from being introduced into the siphon. When this cannot be accomplished, placing a 90-degree elbow on the discharge end pointed straight up will aid in keeping air from entering the siphon. Additionally, an elbow is recommended on the upstream (intake) end of the siphon, which also should be turned up within the reservoir to reduce the potential for sucking in mud, small gravel, and other reservoir bottom debris.

The straight 10-foot long sections of pipe should be connected using the rubber Fernco© fittings. These fittings contain metal tightening bands on each end and are connected by turning the adjusting screw clockwise. The battery-powered drill, with the appropriate attachment, can be used to tighten these bands. The interior surface of the Fernco© fitting and the exterior surface of the pvc pipe must be clean and free of debris. Any type of dirt can cause a bad seal and reduce the effectiveness of the siphon. The pipe can be adjusted within the Fernco© fittings to make a tight straight connection or allow a small amount of movement resulting in an adjustable elbow connection. The tight straight connection is accomplished by butting the two ends of the pipe against each other within the fitting and tightening the metal bands. This action provides a minimal amount of open space between the two sections of pipe, which ultimately locks the pipes together. If open space is left within the center of the fitting, the two sections of pipe can move until they butt against each other. This adjustable elbow connection can be very useful for uneven terrain or small alignment changes.

The section used across the crest should incorporate a means of “priming” the siphon. There are two main methods that have proven useful to prime an emergency siphon. The least complicated method is to use a trash pump to fill the downstream leg of the siphon with water. In order to do this, a threaded plug must be placed on the discharge end, and a tee

section containing a threaded plug must be placed within the crest section of the siphon. In place of threaded plugs shut off valves could be used; however these can be costly items to purchase. The second method replaces the trash pump with a vacuum pump. The vacuum pump is connected to the siphon at the crest section. As a vacuum is induced inside the siphon, water is pulled from the reservoir up the upstream leg of the siphon, and ultimately fills the downstream leg as the air is removed. Once the entire siphon is filled with water, a valve is closed at the vacuum pump connection and the discharge end of the siphon is opened. Using this method requires electricity to operate the vacuum pump, and therefore a generator should be included with the setup. Since this entire operation will take place around or in water, extreme caution should be taken when using electricity. In addition to the generator, an intermediate collection container must be placed between the vacuum pump and the siphon to prevent water from entering the electric vacuum pump.

Using a Vacuum Pump

Using a Trash Pump

As can be seen in the above photos, the use of the vacuum pump is more complicated and requires a great deal of small diameter pipe connections, fittings, and increased setup time.

## Case Studies

The Department has used the siphon trailers and supplies on a few occasions since their implementation. Valuable knowledge was gained and "hands-on" training experience has proven very useful in the operation, setup, and tear down of these systems. Other than one training exercise, every dam where these emergency siphons have been implemented was breached and stabilized.

***Betsy Lake Dam***

The Betsy Lake Dam, owned and operated by the Pymatuning Village Club Allotments (PVCA), was constructed during the 1960s without obtaining a permit from the Department. The dam is an 18-foot high earthen embankment, approximately 460-feet long, located on a 0.6 square mile drainage area in North Shenango Township, Crawford County. This dam did not contain a low level drawdown, and a corrugated steel riser pipe served as the primary spillway. The Division of Dam Safety was unaware of this dam until the fall of 2004 when a site inspection and jurisdictional determination was conducted. This dam was found to be jurisdictional and subsequently classified as hazard potential category 1 or "High" hazard.

On December 27, 2004, the Department's Northwest Regional Office (NWRO) was contacted by a resident of the PVCA regarding concerns about the dam's primary outlet pipe. This call prompted a regional engineer to perform an inspection the following day. This inspection revealed a failure of the outlet pipe between the downstream toe of the dam and a roadway crossing further downstream along the toe, resulting in a large erosion hole. At that time, it appeared as though the PVCA was in the process of removing the roadway culvert and replacing a portion of the outlet conduit. During this process, serious problems with the outlet conduit became apparent. Also, the PVCA had excavated into the toe of the dam to expose the deteriorated spillway conduit and connect a new pipe section. All of this work had been performed without approval from the Division of Dam Safety, or direction of a professional engineer. The Regional Office staff contacted the Division of Dam Safety. Dam Safety advised Regional staff to direct the PVCA to complete the intended repairs immediately, backfill the area, and begin draining the lake. The Department sent a letter on January 10,

2005 to the PVCA requesting the lake be drained and maintained in a drained condition until appropriate plans were developed and approved for the rehabilitation of the dam.

NWRO staff conducted a follow-up site inspection early on January 11, 2005, noting the previous erosion hole had doubled in size, further causing concern for the dam's embankment. NWRO staff notified Dam Safety and the Department's Northwest Emergency Response Program Manager (NWERPM). The NWERPM, Crawford County Emergency Management Coordinator, two members of the North Shenango Fire Department, and representatives from the PVCA conducted an additional site inspection later the same day. The NWERPM conducted a downstream assessment of structures and determined the only immediate threat was to anyone using the downstream roadway should the dam fail.

At this time, only two siphon trailer setups existed within the Commonwealth, one located with the Southwest Region, and one within the Southcentral Region. The NWERPM contacted the Southwest Regional Emergency Response office and requested the use of their supplies. On January 12, 2005, two 6-inch diameter siphons were set up and rendered operational. These siphons were primed using a vacuum pump. At this time, the dam remains breached awaiting a decision from the PVCA to reconstruct the structure. The following photos are from the Betsy Lake Incident.

Temporary Repair Attempt

Downstream Face During Setup

Looking Upstream

Looking Into Lake

Priming Siphon

3 Siphons Running

Hole Within Riser

Breach Section

***Cummingswood Dam***

The Cummingswood Dam, owned and operated by Mr. Charles Vorum, was constructed prior to 1979 without obtaining a permit from the Department. The dam is a 10-foot high earthen embankment, approximately 300-feet long, located on a 0.23 square mile drainage area in Mount Pleasant Township, Westmoreland County. This dam did not contain a low level drawdown, and the primary spillway was an earthen overflow channel. The Division of Dam Safety was unaware of this dam until the summer of 1998 when a site inspection noted a severe lack of maintenance, moderate seepage along the downstream toe, and two depressions on the crest. A downstream hazard potential review found a downstream roadway could be impacted by a small amount of water if the dam were to fail, and therefore, this dam was classified as a hazard potential category 2, “non-high” hazard structure.

From 1998 until 2003, the Division of Dam Safety made several requests to the owner for the development of a schedule to conduct repairs and remove excessive vegetation. Additionally, the spillway capacity was evaluated following a June 2003 inspection. This analysis found that the dam’s spillway was only capable of passing the 5-year storm event instead of the minimum 100-year event specified by State Regulations. Given the owner’s disregard for the Division’s continued requests, the Department issued an Order to drain the impoundment on October 10, 2003. The Order detailed the process for draining and repairing or breaching the dam.

The owner’s receipt of the Order prompted him to call and practically thank the Department for requiring the impoundment to be drained. He wanted to breach the dam anyway, but was concerned about repercussions from local residents and municipal leaders. Since the owner agreed to work with the Department, a decision was made to relax the directed timeframes allowing Mr. Vorum the ability to search for an engineer to develop the plans for draining and breaching the dam. Mr. Vorum’s search continued until late winter 2003 when he advised Division staff the estimated costs to develop the required plans were outrageous. With Mr. Vorum’s inability to fund an expensive project, the Department agreed to develop the breach plans and assist in draining the lake. While the use of the siphons at this dam may not be considered a true emergency, failure of this dam would have caused private property damage and an adverse effect upon the environment.

Two 6-inch diameter siphons were installed by Department staff on April 8, 2004. These siphons operated perfectly for the first day or so, but then began to randomly stop working. It quickly became apparent that local residents were upset with the removal of this lake, and were opening the fill caps to stop the siphons. The Department provided Mr. Vorum with Notices he could post on site to aid in alleviating the vandalism. The following photographs are from the Cummingswood Lake siphon and breach project.

Looking Across Crest

Downstream Area

Seepage/Piping

Primary Spillway

Preparing Fill Section

Connecting Straight Sections

Downstream Face

Impoundment During Drawdown

Breach in Progress

Completed Breach

## Summary

While the use of siphons is limited to specific site constraints, the Department has found these mobile systems very useful in averting potential dam failures. Most of the materials used in constructing these siphons can be easily broken down and reused, providing for an initial upfront investment with minor maintenance and restocking costs. Also, depending on the statutes or regulations of the dam safety agency, these costs along with the cost of manpower, travel, and subsistence could legally be recovered from the dam owner.

In addition to regulating agencies using this equipment, a local municipality, fire department, or individual dam owner could keep or have quick access to siphoning equipment of this nature. In recent scenarios, the Department has used this equipment to construct a few siphons while training the owner or contractor in the proper construction technique. Then the dam owner can purchase additional siphon equipment to construct more siphons in order to accomplish the impoundment drawdown. Training the owner or operator in the set up and maintenance of the siphons alleviates the regulating agency's personnel from remaining onsite allowing them to return to normal operations or assist at other facilities during a widespread emergency.

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