



**The Power of Water Is Impressive!**

# **FLOTATION (BUOYANCY) COMPARISON**



American **Concrete Pipe** Association

## Flotation (Buoyancy) Comparison: Concrete vs Flexible Pipe

Buoyancy forces that affect a buried pipeline should always be a design consideration. In most cases, concrete pipe because of its density, will **not** float. Conversely, flexible pipe, which has been touted as “lightweight and easy to install”, is extremely susceptible to flotation problems.

Final installation conditions must be considered in any design. Special consideration must be given to installation conditions with high probability of flotation:

- Pipelines in areas subject to flooding.
- Areas with a high groundwater table.
- Where flooding is used to consolidated backfill.

## Why Flexible Pipe Floats When Precast Concrete Pipe Won't!

The average density of concrete pipe is 150 lbs./cu.ft. which is 2.4 times that of water. However, the density of corrugated polyethylene (PE) pipe with an interior liner (a flexible pipe representative) is as much as 6 percent less than that of water. There have been numerous occasions of backfilled corrugated PE pipe which have floated above the surface of the ground. While the following discussion is applicable for most flexible pipe, PE pipe has been chosen for this example calculation.

Example: 24' dia. pipe with 2 feet of earth cover and groundwater table near the surface.

(For calculation purposes and safety factor, pipe is considered empty)

Concrete pipe – downward force is approximately 1.6 times greater than the upward (buoyant) force, meaning the pipe will not float.

Corrugated PE pipe – downward force is approximately 0.8 of the upward (buoyant) force, meaning the pipe will float.

In the above example, if the PE pipe had aggregate backfill with 2 feet of cover, the downward force would be approximately 1.6 times greater than the upward (buoyant) force. However, even with the use of aggregate backfill, the PE pipe will float with approximate cover of 14 inches or less.

Flexible pipe flotation at culvert inlets has also been a frequent occurrence. Some have resulted in complete jetting of the culvert from the roadway. Others have resulted in collapse of the culvert and the roadway.

# The Proof is in the Pictures...

## Saukville, WI

After completion of the site work for a Wal-Mart store, a portion of a line of 36-inch diameter corrugated polyethylene pipe with an interior liner floated out of the ground. This line was part of the parking lot drainage. The pipe had approximately one foot of cover. Fortunately, the pavement had not been completed at this time.



## St Paul, MN

The pipe used in a ditch realignment project was 24-inch diameter corrugated polyethylene pipe with interior liner. Although the pipe was installed parallel to the ditch and with two feet of cover, two sections of the pipe floated out of the ground after a day of steady rainfall.



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## Chattanooga, TN

Even though it was full of water and had a cover of 12 inches of crushed stone, a 48-inch diameter corrugated polyethylene pipeline floated out of the ground three times. When the developer revealed plans to use HDPE pipe in lieu of concrete pipe, the engineering firm requested in writing to be released from any responsibility and liability. Therefore, the expenses of reinstallation of the HDPE pipe were borne by the developer and the contractor.

## New Braunfels, TX

The corrugated polyethylene pipe with interior liner floated on one end of a street crossing after heavy rainfall. This installation consisted of two lines of 24-inch diameter pipe with approximately one foot of cover under pavement.



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## Baton Rouge, LA

The contractor was in the process of connecting the catch basins to this 18-inch diameter corrugated polyethylene pipe with interior liner when a sudden downpour caused it to float out of the ground. The pipe was being installed under a parking lot with approximately 15 inches of cover.

## San Antonio, TX

A few hundred feet of a double 108-inch diameter corrugated metal pipeline floated completely out of the ground after heavy rain. The pipe, which received water from a ditch with a paved inlet, had approximately two feet of cover.





## Columbia, SC

This 24-inch diameter corrugated polyethylene pipe with interior liner floated up on the inlet end of a road crossing. Therefore, considerable ponding and roadway overtopping occurred. This pipe had approximately 15 inches of cover.

## Loxley, AL

Three pieces of a 30-inch diameter storm drain line floated out of the ground between inlet boxes. The pipe, corrugated polyethylene with interior liner, had been installed in a proposed parking lot. At the time of the flotation, the pipe had approximately one foot of cover.

## Waukesha, WI

This 24-inch diameter corrugated metal pipe was installed under the entrance to a new housing subdivision off Cleveland Avenue. Heavy rains and runoff from the construction site and the surrounding area caused one end of the pipe to float out of the ground. The pipe had approximately 30 inches of cover.





## Sheldon, IA

A triple line 24-inch diameter culvert under a bicycle/walking trail floated out of the ground after very little rainfall. The corrugated polyethylene pipe had approximately one foot of cover. The pipe was reinstalled with the

inlet ends encased in concrete.

An approximate 1/2" rainfall caused one of the three lines to separate and blow outward on the outlet end.



## Milwaukee, WI

During construction of a parking lot a line of 24-inch diameter corrugated polyethylene pipe with an interior liner floated out of the ground. This line was to be used as drainage for the parking lot and the adjacent grass property of a homeowner. The pipe had 26 inches of cover. Approximately 10 inches of pipe height was exposed, causing the homeowner's lawn to buckle along a 330' length.

## Maple Grove, MN

These photographs depict a culvert installation under a gravel access road to Interstate 94 in Maple Grove, Minnesota. The installation consists of two 20-foot sections of HDPE pipe joined with a coupling band. A rainstorm and subsequent drainage created upstream ponding at the culvert. Hydrostatic forces caused the upstream 20-foot section to float out of the ground. The ponded water also overtopped the gravel access road, saturated the entire roadbed, washed-out a portion of the roadbed and rendered the access road impassible.



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## Kansas City, MO

This culvert drains a church parking lot just west of Kansas City, Missouri. It is installed in an open field with no live load. Water ponds near the outlet of the HDPE pipe. The hydrostatic forces have caused the coupling bands and end section of the HDPE line to become dislodged and ineffective.



## Bluffton, OH

Heavy rains in Northwest Ohio cause Riley Creek to overflow its banks flooding Interstate 75 and the Bluffton Quarry near Bluffton, Ohio. Approximately 100' of 36" HDPE pipe had been installed along the quarry levee to carry storm water from I75 to Riley Creek. The storm caused the HDPE pipe to float and have joint failure due to internal pressure. The HDPE piping had minimal cover and did not appear to have any ODOT approved bedding or backfill material. A number of the HDPE pipe sections completely floated away, ending up at the bottom of the quarry. This was the second time in four years (2003) that the HDPE pipe installed in this location did not stay in place.



## Caldwell Parrish, LA

Fall weather is typically dry in Louisiana. However heavy rains caused several hundred feet of PVC storm drain pipe to float out of the ground on this highway project. The pipe had been covered with the one foot of granular backfill material as required by the project specifications.

## Minnesota

Three reinforced concrete culverts were installed under a gravel roadbed in northern Minnesota. The watershed for this area received an abnormal amount of rainfall. Hydrostatic forces resulting from the storm washed-out the gravel roadbed. However, the concrete pipe remained in place because of its weight and the use of pipe joint ties. This allowed quick replacement of the roadbed and vehicle access to the area.



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