STEVE WRIGHT

- BSE Agricultural Engrg. Wash. State Univ. 1971
- MSE Hydraulic Engrg. Wash. State Univ. 1973
- PhD Civil Engrg. Caltech 1977
- Faculty CEE Univ. Michigan 1977-2018
- Early research in stratified flows prepared my well for two phase flow research in sewers
- Design consultant and Technical review, various CSO storage tunnel projects including Toronto's Don River and Central Waterfront projects

A New Look at Geyser Formation in Sewer Systems

Steven Wright, University of Michigan

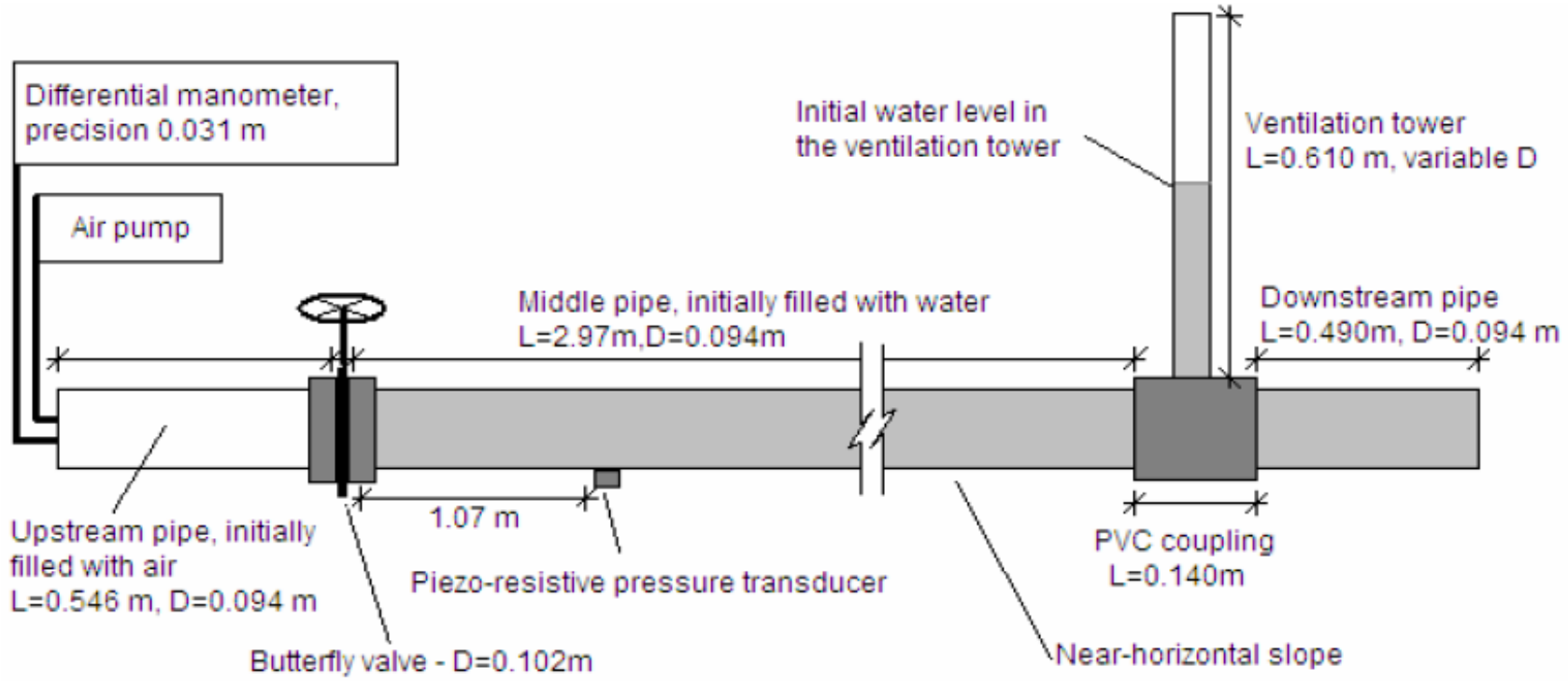
CONTEXT

- Sewer geysers observed in various locations in TARP system in late 80s, 90s continuing more recently.
- Charles Song (U. Minn.) studied this problem and developed computer model of sewer filling 90s
- MnDOT had problem with stormwater tunnel geyser in Minneapolis. Received copy of 2004 geyser video in about 2005
- Showed video plus lab video at 2006 CHI conference
- At a conference in 2006, learned that U. Minn. Did field study for MnDOT, measured velocities and pressures
- Received data from MnDOT in late 2007 for 2004 video
- Additional lab experiments informed by field data
- Began to receive other videos from other systems and located others on YouTube
- A few years back, went through the collection to see if there were any lessons to be learned

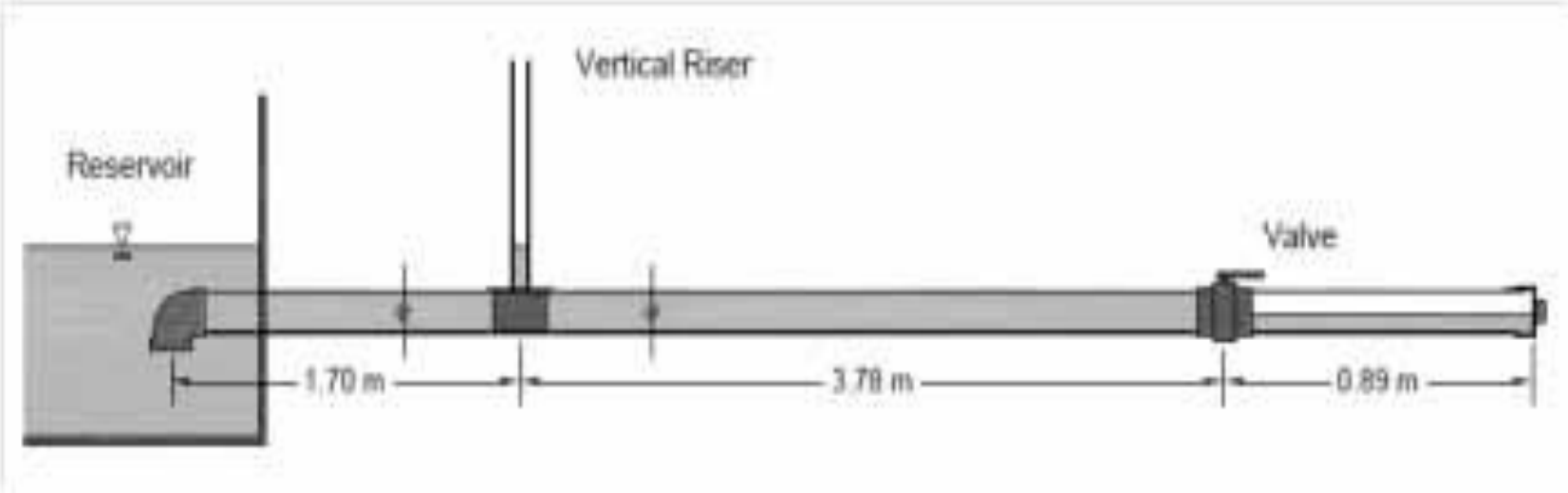
An Odd Geyser

The Original Lab Video

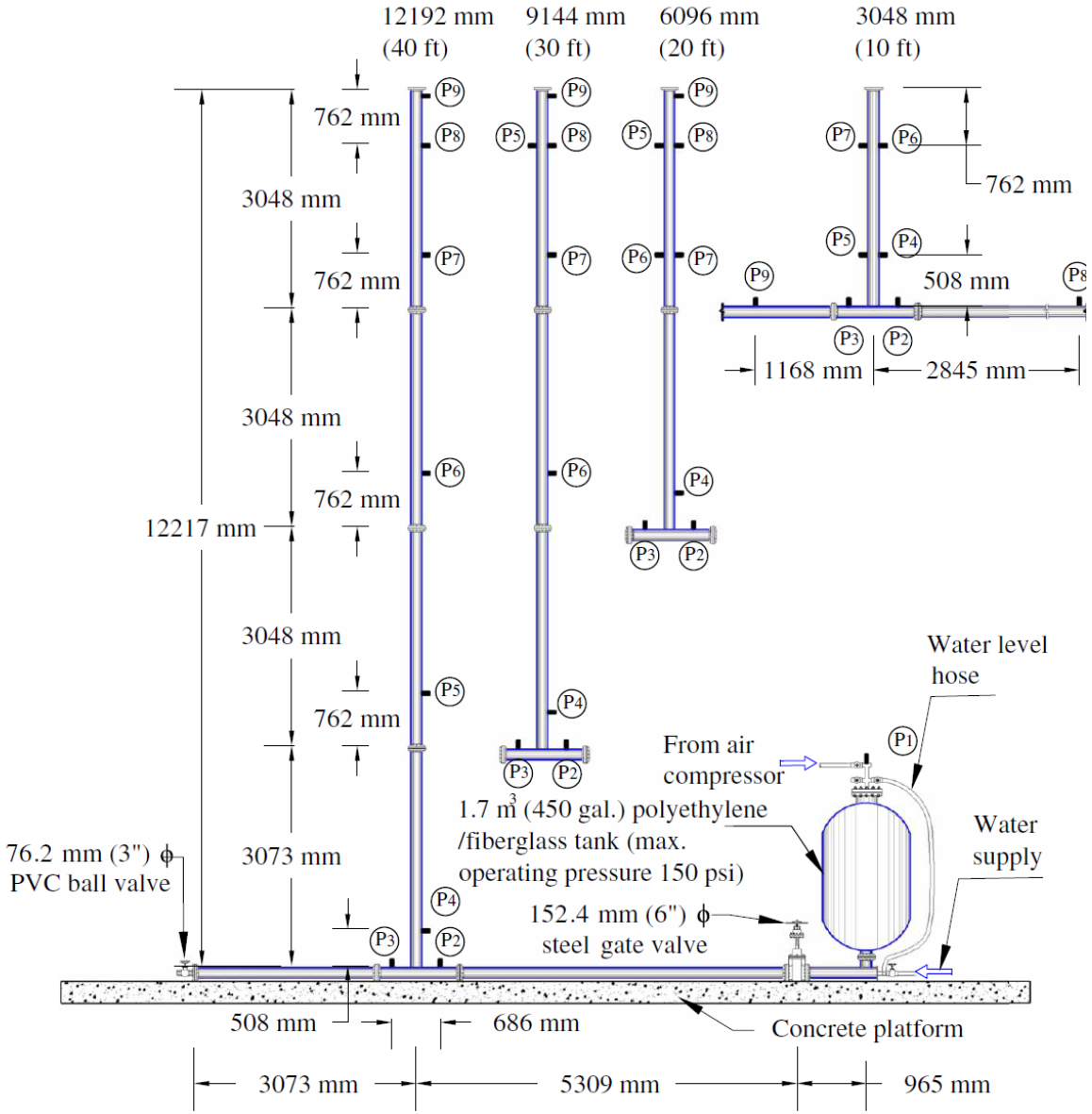
Early Lab Setup



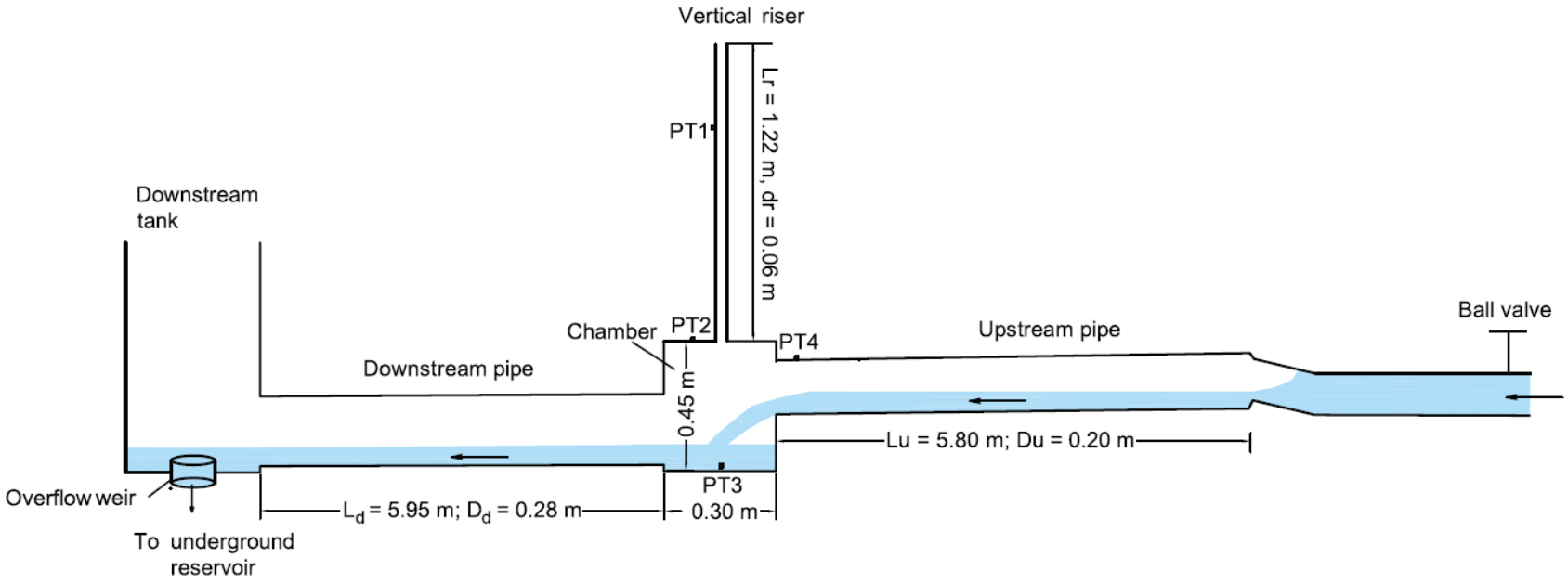
After Modification



Another Version



Model of System in Edmonton



(a)

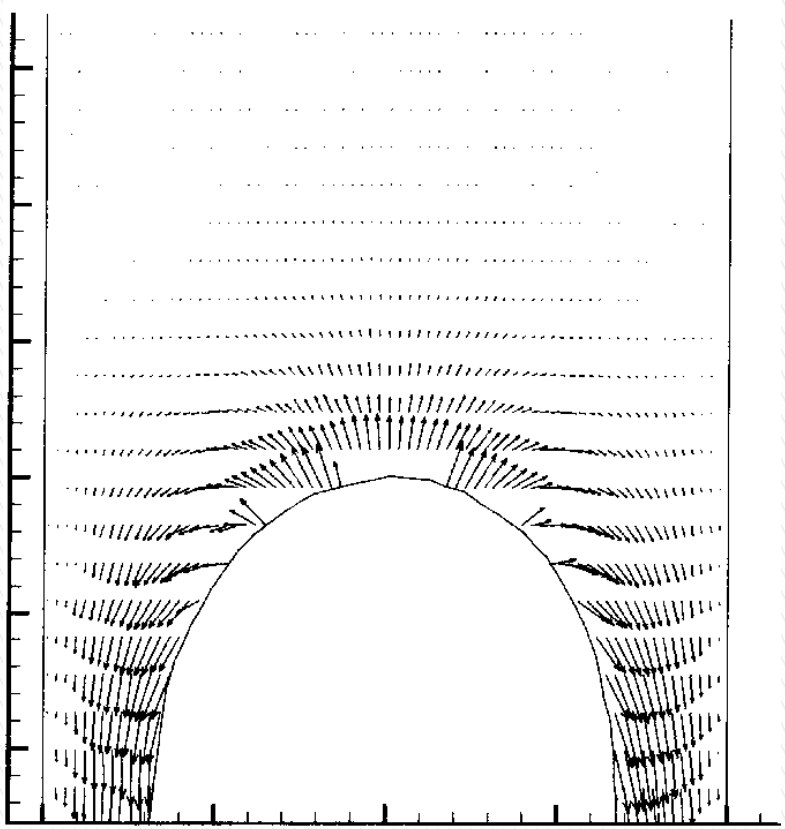
General Results of Lab Studies

- Possible to produce eruptions through vertical shafts from release of air volume into horizontal conduit
- Air arriving at shaft rises due to buoyancy pushes water ahead of it and exits the shaft somewhat explosively
- Air volume can break up resulting in several eruptions of water forced up by air
- Leon, et al report 3-8 geysers over 8-10 seconds, Liu, et al, geysers at about 1 second spacing.

Do Lab Studies Reproduce Geysers?

Original Hypothesis

- Assumed rising air behaved similarly to Taylor Bubble. Shear flow instabilities between falling water and rising air entrains water into air flow which is carried upwards in the geyser



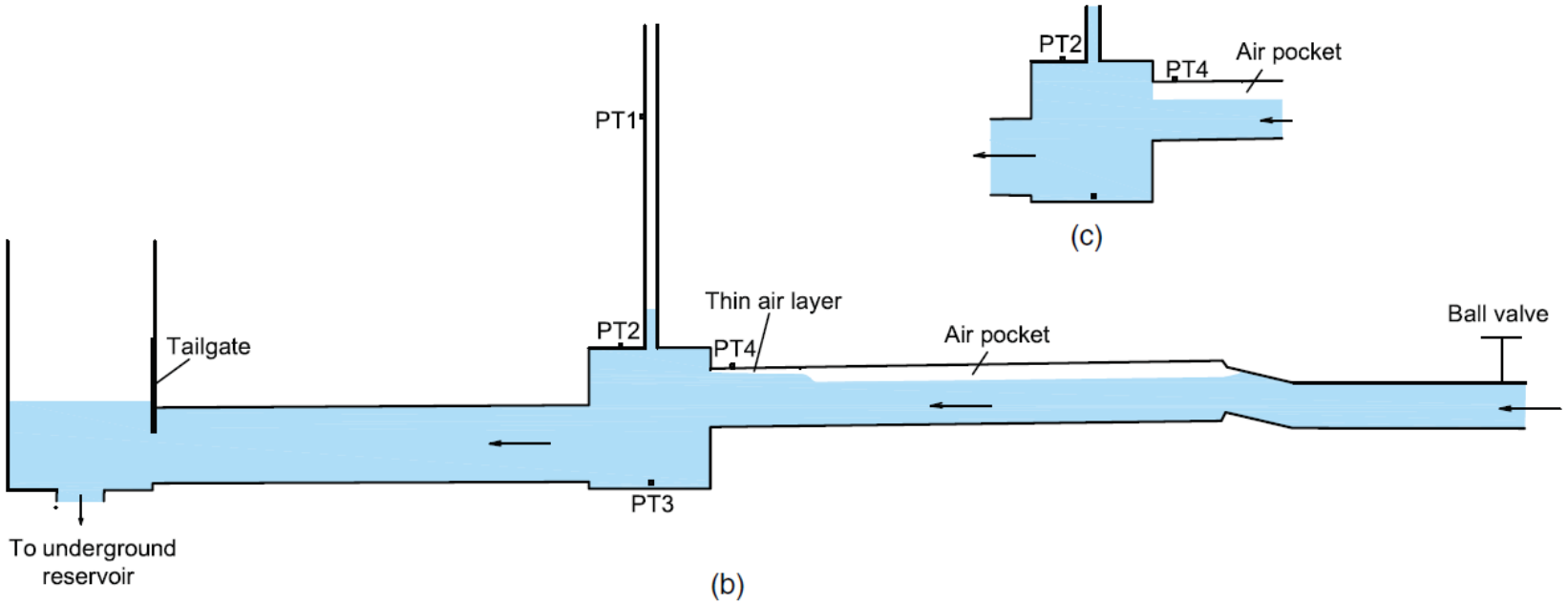
Inconsistencies

- In Minnesota geyser, estimates suggest geyser velocity about 20 m/s and water/air ratio of about 4%. Surcharged water in riser would be evacuated in about 1.5 seconds, not counting the initial water displaced ahead of air. Those geysers lasted about 20 seconds
- **Leon, et al** suggest that instabilities in horizontal flow result in development of slug flow and air and water mix in that way. Could explain their lab observations, but not long-lasting field geysers in the videos.
- Must be another mechanism that provides source of water for duration of air pocket discharge through shaft

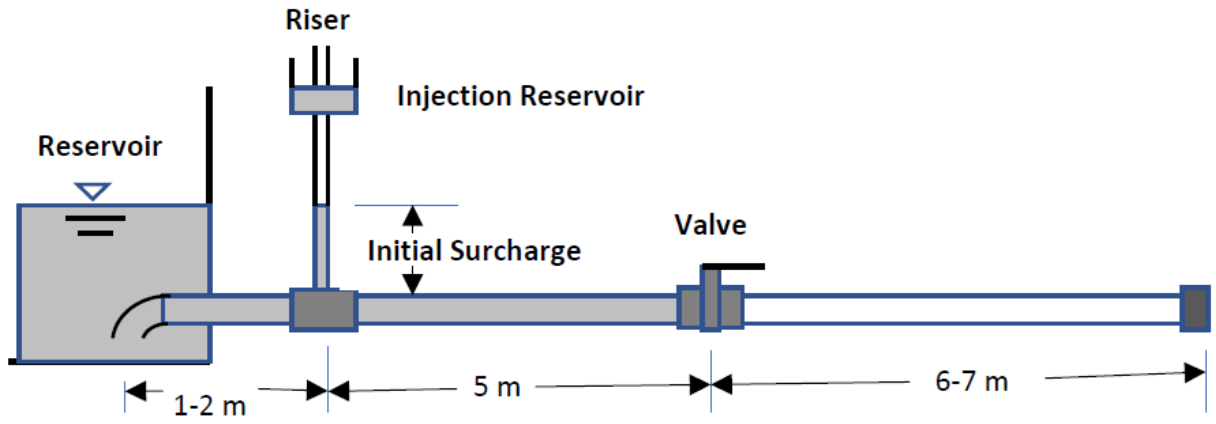
Source of Water

- Specific geometry of most systems in geyser videos is unknown
- Minnesota geyser shaft serves as a dropshaft for 72-inch storm sewer just below grade and with water dropping about 25 m
- Some of the other videos have known water falling from the surface
- Something like this or similar could provide the extended source of water

Liu, et al Geyser Configuration



Modify Experiments Once Again



Potential Difficulties

- Surface tension effects are over-emphasized in smaller Froude-scaled model
- Would result in larger droplets than dynamically similar flow would require
- Adjust water injection configuration and rate so that water droplet formation is enhanced,
- Use a lot more air than any previous experiments but still wouldn't scale
- Increase initial surcharge to increase vertical gas velocity

CONCLUSIONS

- Initial studies have almost certainly not elucidated the details of geysers which appear to be water-air jets maintained over the duration of the air escape
- There are likely to be different configurations that provide a water source sufficient to maintain the geyser
- Some of the general conclusions from initil work is likely to be qualitatively valid (effect of riser diameter, etc.)
- Large trapped air volumes are somewhat common