Low-cost, methane sensor for in-situ ebullition measurement

Context:
WSU Bio-geochemistry lab's methane ebullition study- an attempt to characterize methane emissions from Lacamas Reservoir, identifying spatial and temporal trends in methane ebullition and associated environmental and management factors.

Current data collection methods:

- Weather and management data -- provided by external sources (weather stations, reservoir management).
- Temperature and oxygen profiles – in-person, semi-weekly, water-column measurements.
- Dissolved methane, oxygen, and other nutrients – samples taken in conjunction with other water-column measurements and processed in-lab at a later date.
- *Methane ebullition* – array of ~15 methane traps distributed throughout Lacamas (active and passive) which collect bubbling methane for later extraction and in-lab processing.

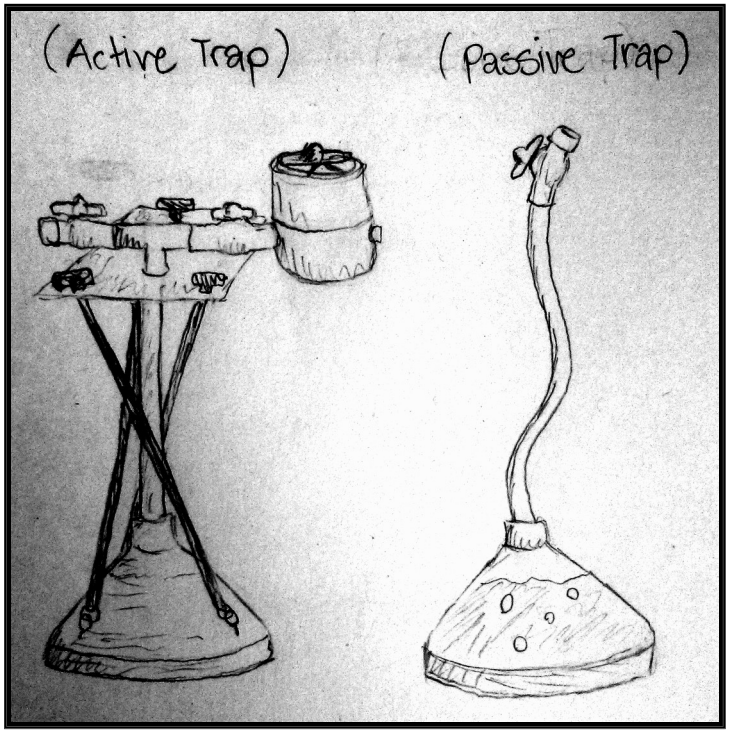
Current Methane Traps:

Capabilities:

- Real-time, gas volume measurements. (30sec resolution)
- Provides average concentration of collected gas after high-resolution (+/- 2%) in-lab analysis.
- Passive traps do not require power source.

Limitations:

- No real-time concentration values (extracted samples require in-lab processing and represent average concentration over collection period only).
- Finite gas capacity (<1000ml), requires frequent extraction (every couple days/weeks depending on ebullition rates).
- Extracted samples require additional in-lab processing (time and money).



Potential, in-situ Methane sensor:

Desired Capabilities:

- Real-time, gas volume and methane concentration measurements (more time-correlated data).
- Gas released after measurement (no capacity limitation, less frequent in-person maintenance).
- No in-lab analysis necessary (saves time).
- Affordable to replicate (maintain spatial resolution provided by current traps)

Anticipated Limitations:

- More electronically/mechanically complex (more points of failure).
- Less precise concentration measurements than samples processed in-lab.

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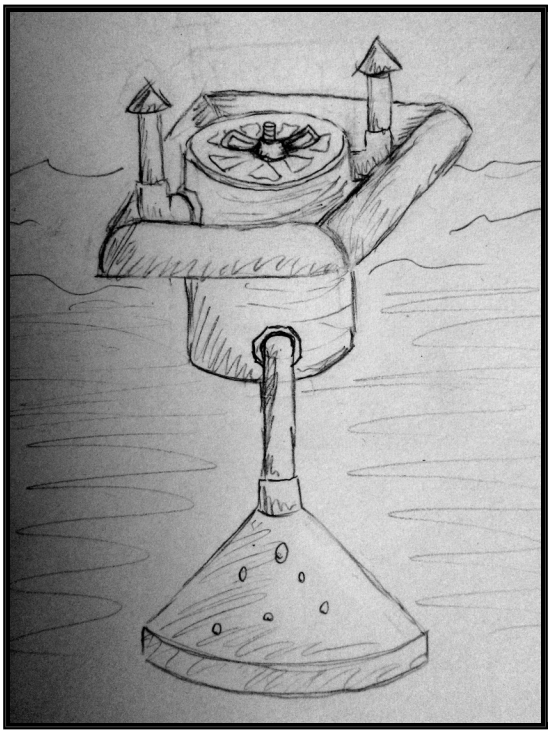
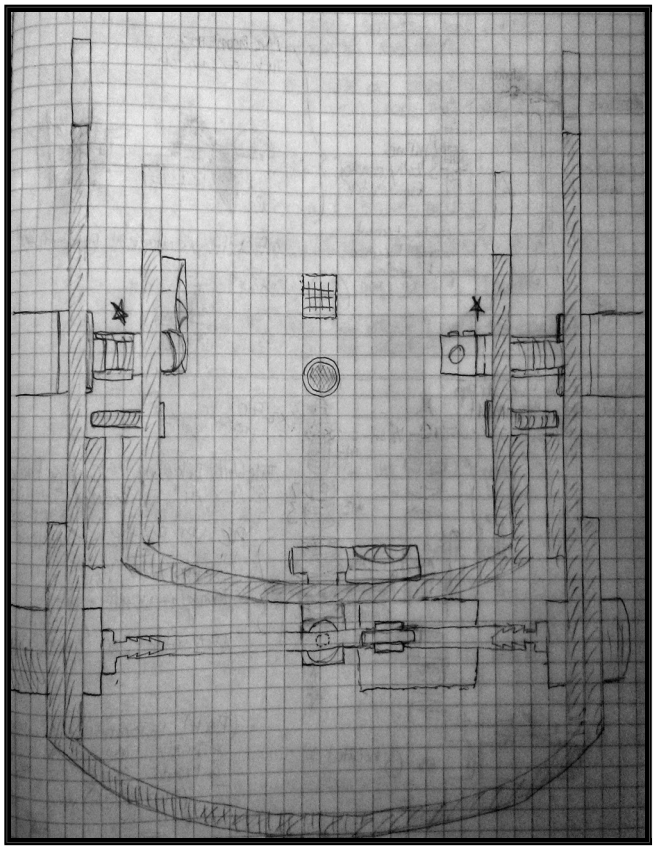
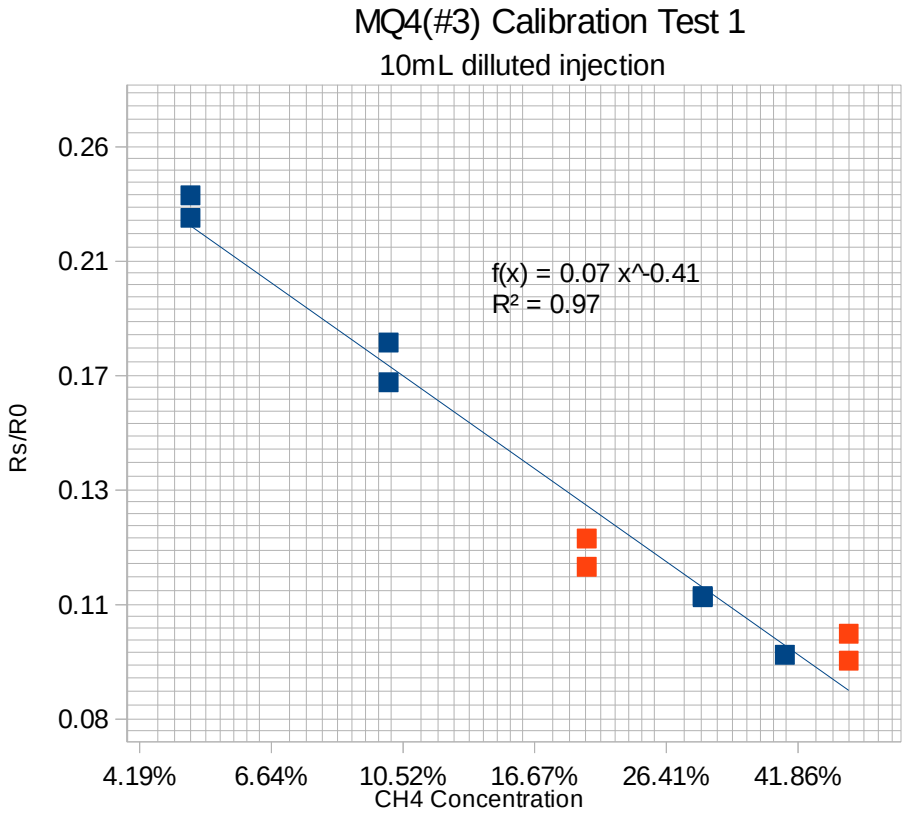


Current design and constraints:

- Utilizes MQ4 Tin-oxide, solid-state methane sensor, RHT03 relative humidity and temperature sensor, and current active-trap pressure sensor.
- Requires continuous access to atmosphere for venting and accurate reading.
- Solid state sensors max out at 10% methane concentration, requiring dilution chamber.



Current stage of development: Constructed test chamber. 'Burning-in sensors", Testing methane sensor's precision, accuracy and behavior at various concentrations and under various humidity and temperature conditions and comparing to manufacturer's results.



Next steps:

Ideally, after compensating for humidity and temperature, the linear correlation between relative resistance and absolute concentration can be replicated and development can move onto construction of field chamber.

Technical Parameters of MQ-4 Sensor

Model			MQ-4
Sensor Type			Semiconductor
Standard Encapsulation			Bakelite, Metal cap
Target Gas			Methane
Detection range			300～10000ppm(CH_4)
Standard Circuit Conditions	Loop Voltage	V_c	≤24V DC
	Heater Voltage	V_H	5.0V±0.1V AC or DC
	Load Resistance	R_L	Adjustable
Sensor character under standard test conditions	Heater Resistance	R_H	26Ω±3Ω(room tem.)
	Heater consumption	P_H	≤950mW
	Sensitivity	S	Rs(in air)/Rs(in 5000ppmCH_4)≥5
	Output Voltage	Vs	2.5V～4.0V (in 5000ppm CH_4)
	Concentration Slope	α	≤0.6($R_{5000ppm}$/$R_{1000ppm}$ CH_4)
Standard test conditions	Tem. Humidity		20℃±2℃; 55%±5%RH
	Standard test circuit		Vc:5.0V±0.1V; V_H:5.0V±0.1V
	Preheat time		Over 48 hours