TP-DownHole: a ruggedized open-source pressure and temperature sensor designed for water-level measurements

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Acknowledgments

Funding

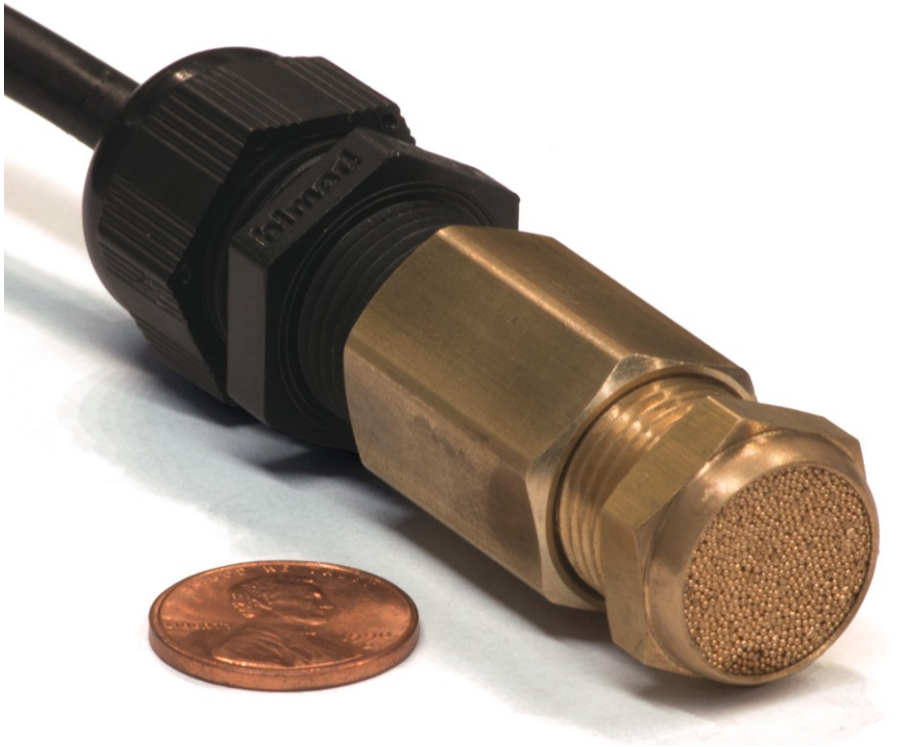
- University of Minnesota

- WMO HydroHub

And: encouragement and enthusiasm from the community

Overview

1) Background: objective in making water-level measurements
2) Development and production (and how to build your own)
3) Data logging
4) Example use cases
    a) Oil spill (Iowa USA)
    b) Manoomin/Psiŋ (wild rice)



Why water level?

- One of the most **routine** environmental measurements
- Gradients in water level provide information on **discharge**
- Widely **applicable** across multiple academic fields, government / public service, and industry

- Why **Pressure?**
  - Both **surface water** and **groundwater**
    - So we want to support long cables for deep measurements
    - And we want to screen out sediment
- **Temperature** as well
  - Important tracer
  - Straightforward measurement

Why water level?

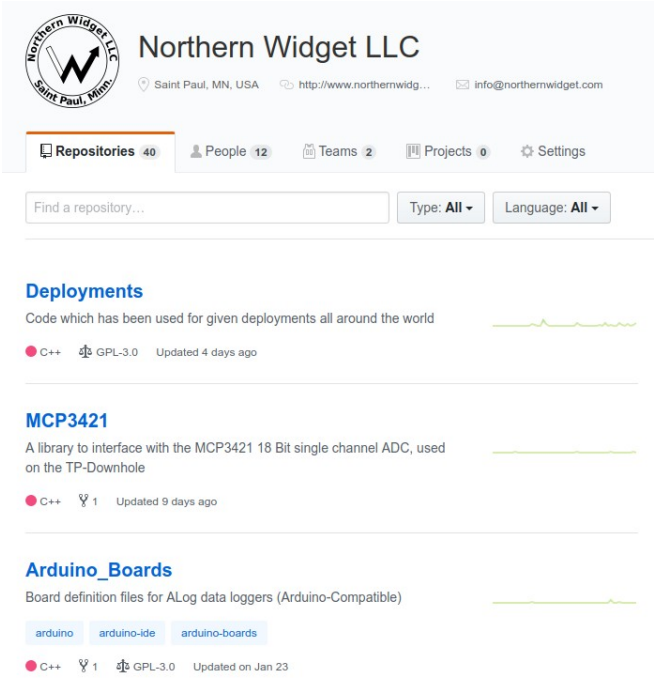
- Many sensors exist
  - Schlumberger Diver
  - Solinst LevelLogger
  - Onset/Hobo
  - …

- Our goals
  - Open source
    - Know all potential errors
    - Easily modify/upgrade
    - Can construct your own
    - “Farm-to-Table” science
  - Less expensive
    - Water pressure
    - Barometric correction
  - Telemetry with proper logger

Open-source development

- Copyleft
  - Software: GNU GPL v3
  - Hardware: CC BY-SA
- Facilitates free flow of knowledge between university and company
- Facilitates collaboration between and among many small groups: required to be competitive

Open-source development



- All code, hardware designs, and documentation are available on GitHub
- Open-source approach eases publication

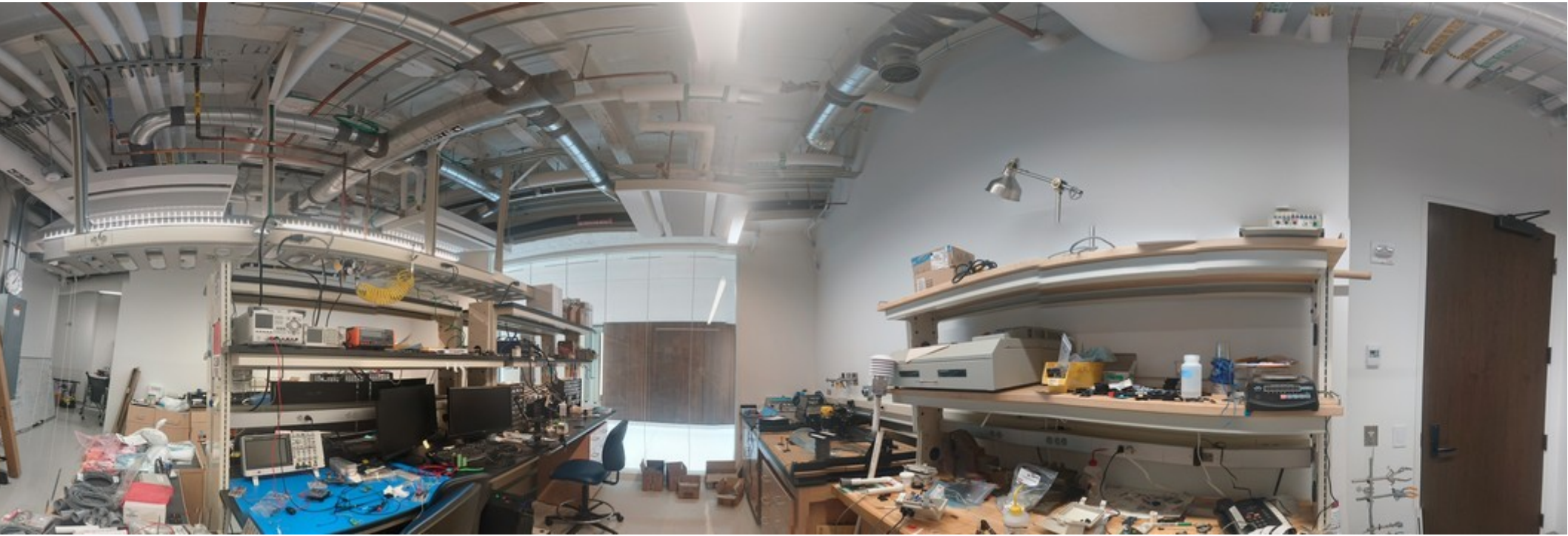
Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2018-591
Manuscript under review for journal Hydrol. Earth Syst. Sci.
Discussion started: 7 December 2018

Hydrology and Earth System Sciences
Discussions

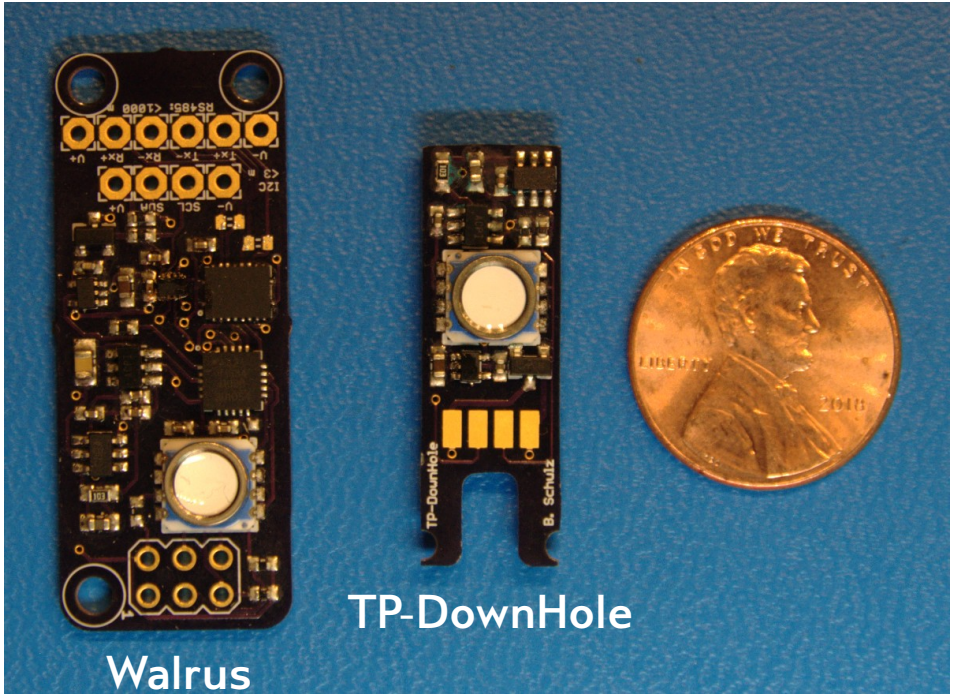
Open-source Arduino-derived data loggers designed for field research

Andrew D. Wickert[1,2,3], Chad T. Sandell[3], Bobby Schulz[1,3,4], and G.-H. Crystal Ng[1,2]

Development lab – University of Minnesota



The TP-DownHole and (TPDH)-Walrus



- "Temperature-Pressure Down Hole"
- TP-DownHole (~$35 parts, $200 built)
  - Original design, board 9.53x28.96 mm
  - After encapsulation, can fit in 1/2" (barely) or 5/8" (more easily) tubing for multi-level wells
  - Potted in epoxy via injection molding
- Walrus (~$35 parts, $150 built)
  - Single-sided board for easier assembly
  - Can pot in pour-over resin
  - Board: 16x40 mm

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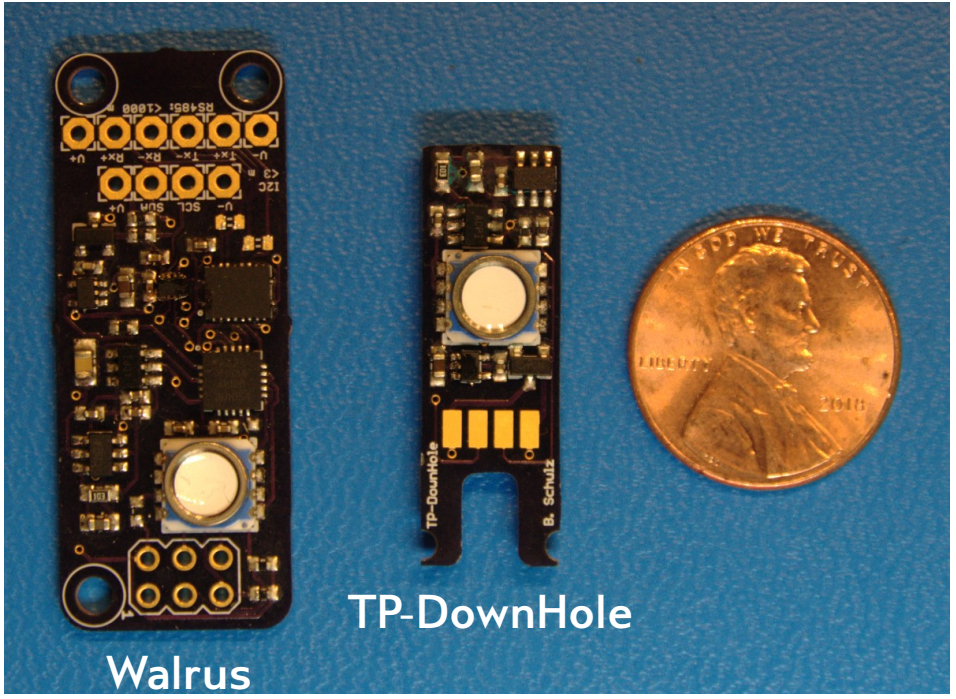

- Pressure transducer
  - MS5803-series MEMS
  - ~$15
  - Different models from barometric to 300 m water depth
  - 2 atm model is precise to 1–2 mm
- SMD thermistor with voltage divider and ADC
- ATTiny1634 microcontroller with custom firmware; communicates with logger
- Communications (both)
  - I^2C (3 m or less)
  - RS485 (< 1 km)

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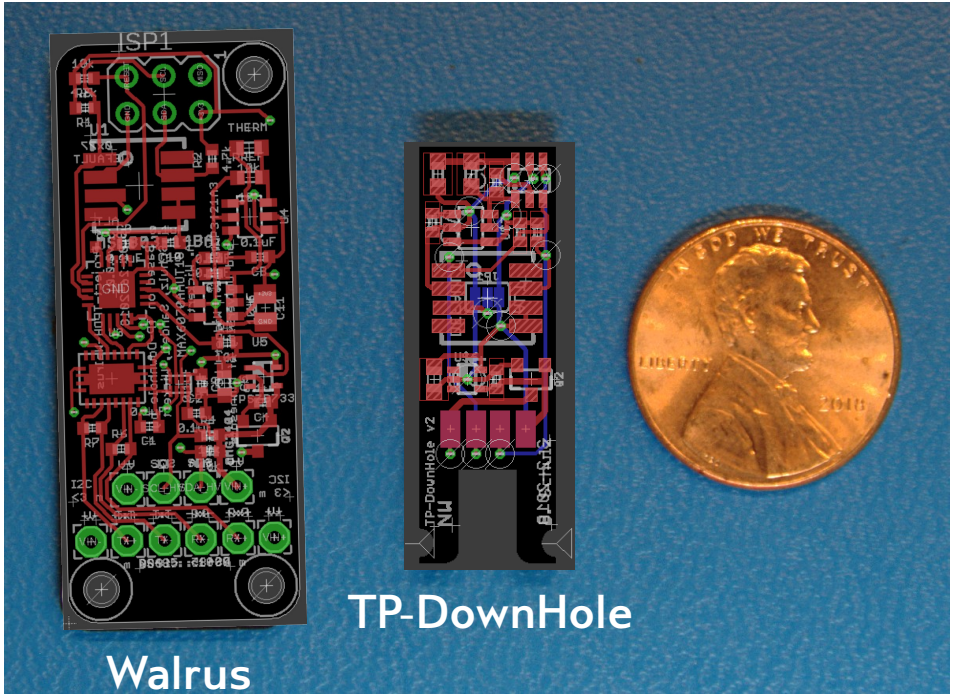

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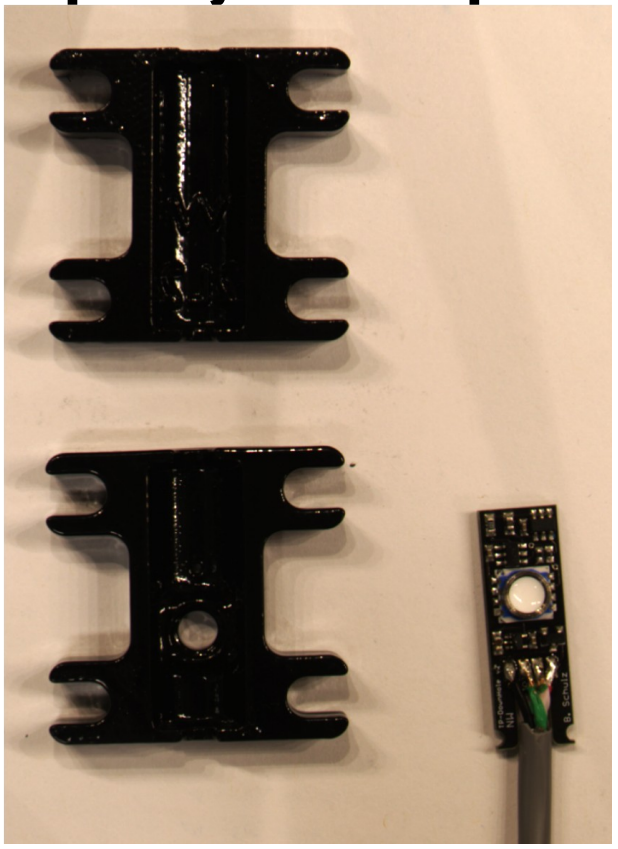
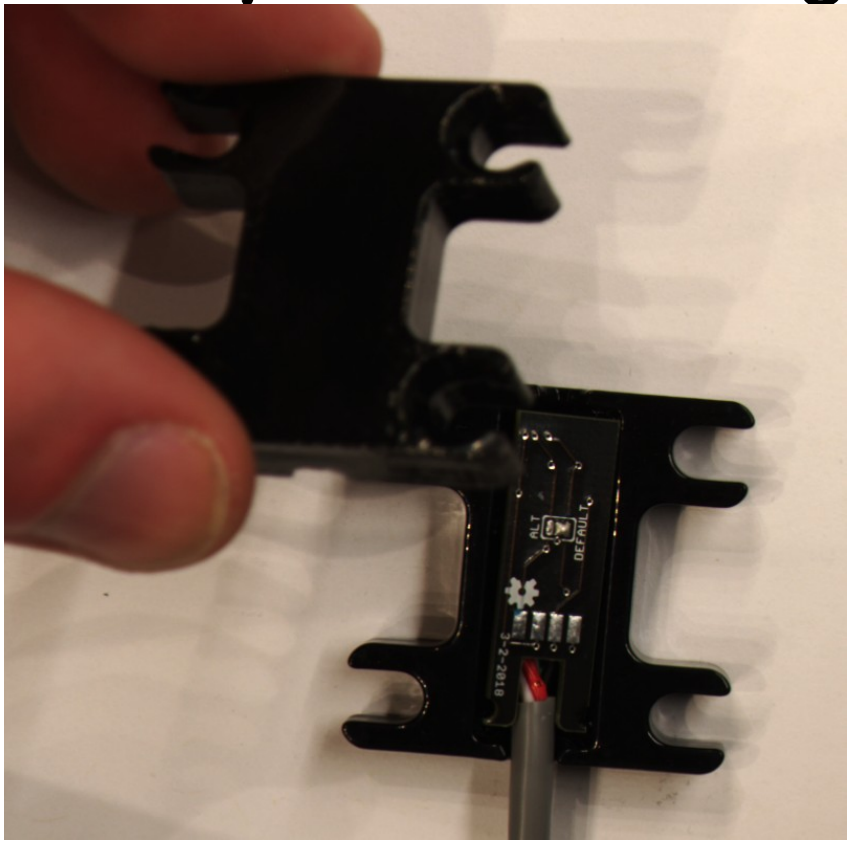
Epoxy encapsulation: injection molding





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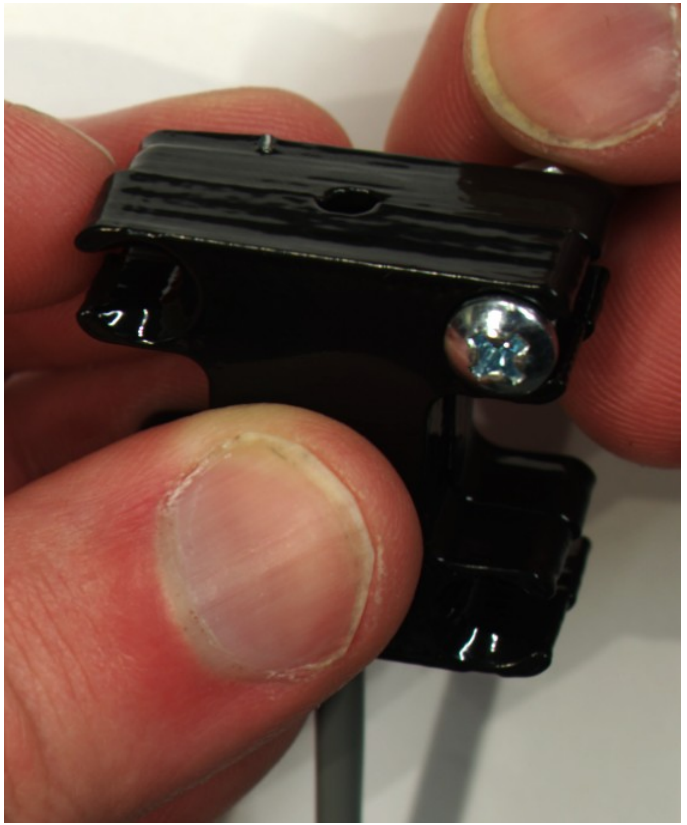
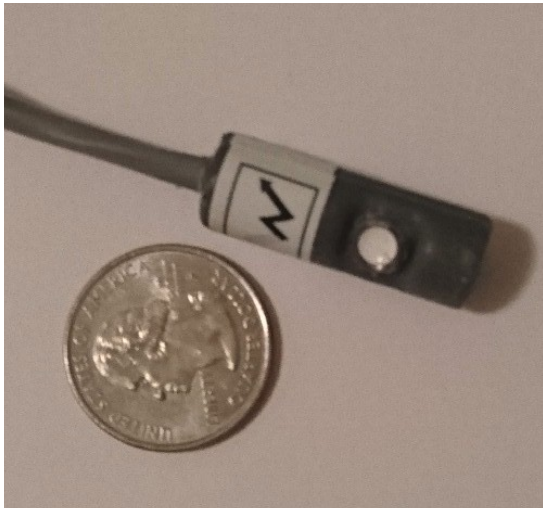
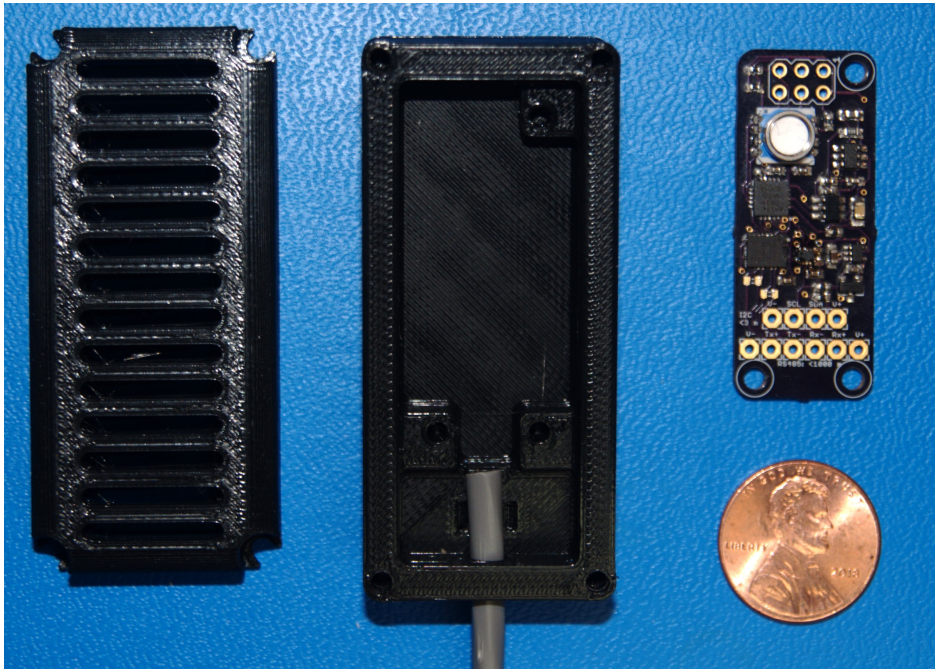


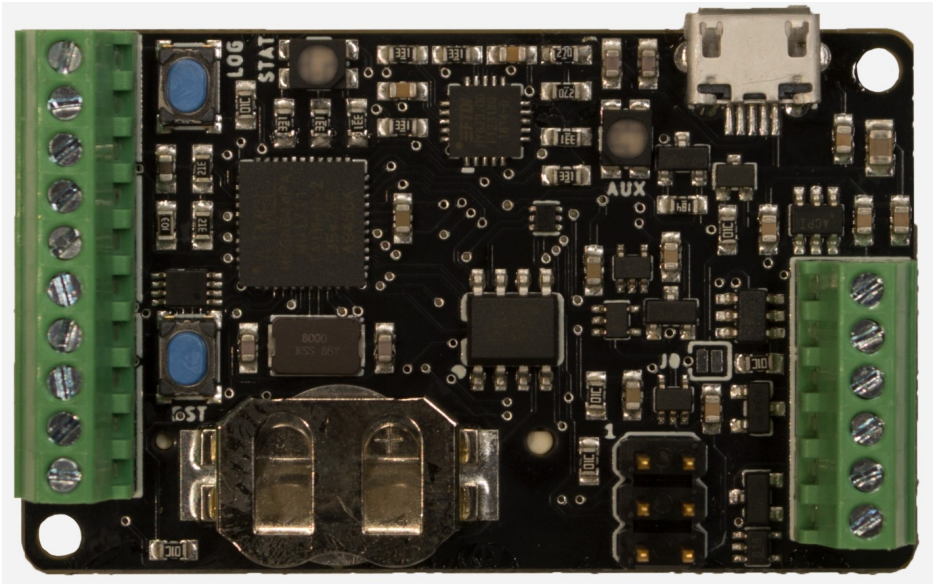


TPDH-Walrus: Simpler pour-over housing



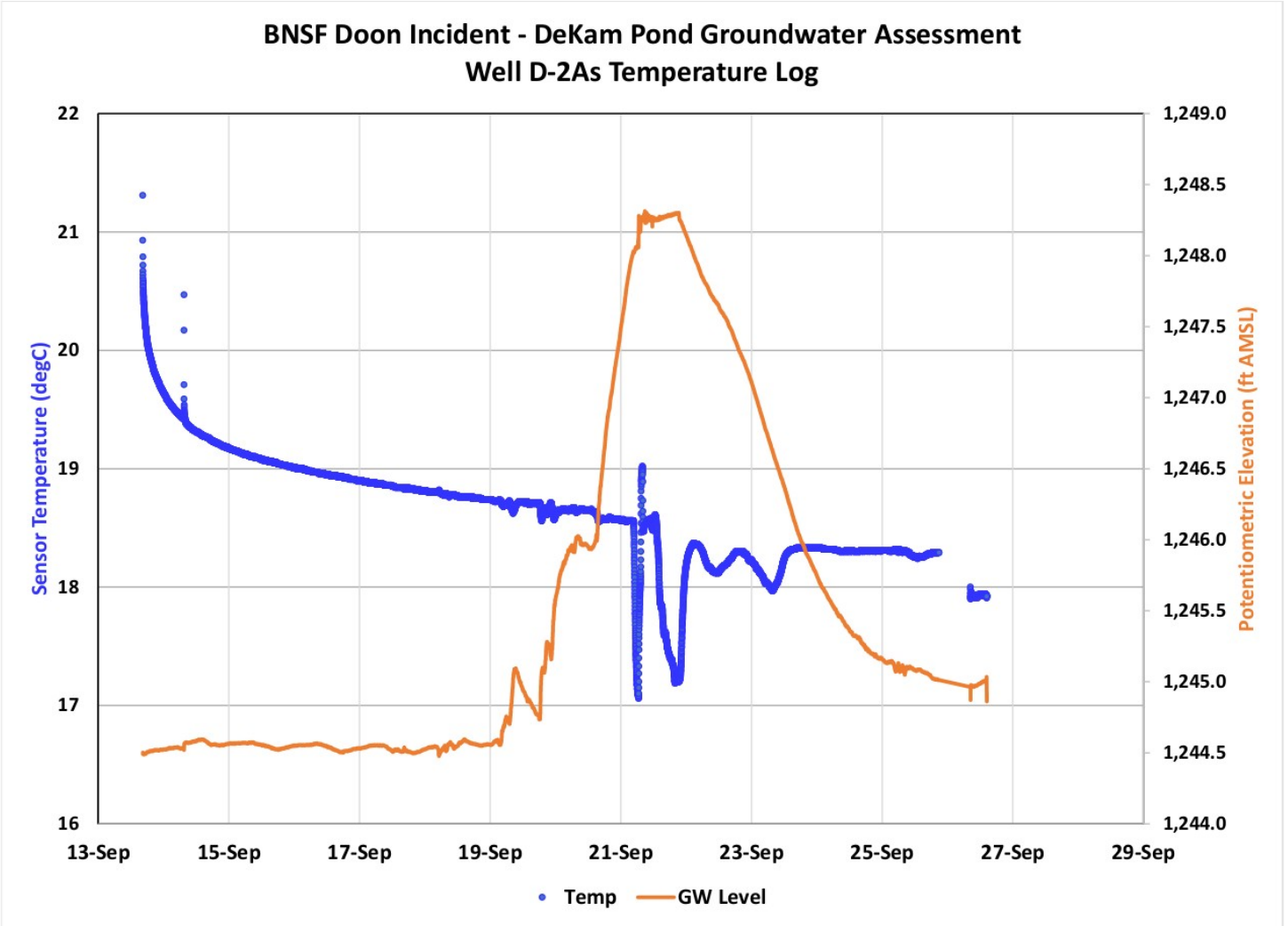
- Attach to bottom with screws
- ICSP header can remain exposed / accessible in case firmware updates are needed
- Simple 3D printed housing
- 3D printed screen – or can substitute a user-selected mesh to better filter sediment

Logging the data



- Margay data logger: v0.2 (expected April 2019) has built-in barometric pressure measurement (BME-280)
- Resnik data logger (expected May 2019): telemetry and built-in barometric pressure
- Any data logger that supports I^2C or RS-485.

Groundwater flow after an oil spill in Iowa, USA



Response to:

- Natural hydrology
- Tests by Rapp's team

Monitoring wild rice lakes (Minnesota & Wisconsin)

- Concerns about sulfur geochemsitry – reduction to H_2S can be toxic for roots, but depends on reactive transport
- Need to monitor water levels and groundwater flow paths
- Multiple stakeholders and legal structures
  - Treaties with Ojibway
  - Fe/Cu/Ni Mining
    (Pt/Pd mining possible soon)

Deployments

Summary

Open-source data logger for water level (and temperature). Low cost – and you can build yourself!

github.com/NorthernWidget
github.com/NorthernWidget-Skunkworks