

Advancements in Remote Sampling and Data Collection on the Berkeley Pit

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Brief History of the Berkeley Pit

- **1955 Open Pit mining started in Butte, MT**
- **1982 the Berkeley Pit was abandoned and allowed to fill with water**
- **Presently: surface area about 700 acres**
 - About 850 ft deep
 - 50 billion gallons
 - pH currently 4.2
 - Currently being pumped to maintain level



Berkeley Pit 1970's

History of Sampling

- **Adjacent to an active mine site**
- **Part of the largest EPA superfund site**
 - Maintain below an established elevation
 - Semi-annual water sampling and profiling
 - Until 2013 sampling was performed manually
 - Slope failure in February 2013 ended manual sampling due to safety concerns
 - 2014 Montana Tech commissioned to create a remote sampling system
 - 2017 initial design was launched
 - 2025 Sediment Sampling boat anticipated



Sampling Requirements

- **Operate without operator being on the water**
- **Profile the water down to 650 ft at a specified GPS location**
- **Provide profile data for analysis**
- **Sample the water at multiple depths up to 800 ft**
 - Capability to hold multiple samples and keep track of samples
 - Capability to specify the desired depth of the sampling
 - Return with samples for analysis
- **Perform Bathymetric Survey of the Berkeley Pit**
- **NEW* Sample sediment up to 800 ft**

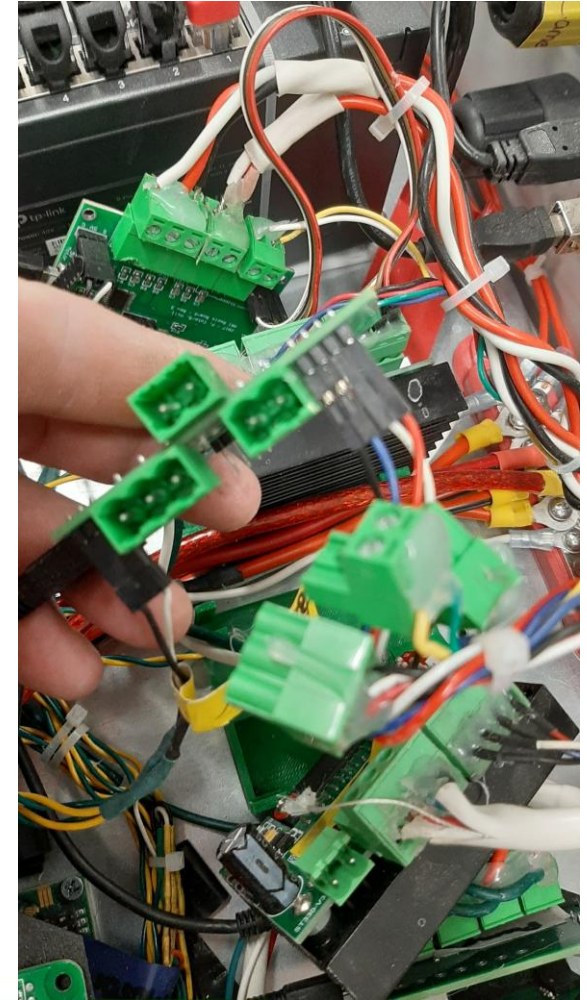
Initial Design (2017)

- **Drift Boat with two fixed electric drive motors (skid steer)**
- **Modified ISCO sampler for water collection**
- **Mechanized hose reel and Data reel**
 - Motorized main motor
 - Linear stage for level wind
 - Feedback from switches and rotation
 - Hose Reel capable of up to 800ft depth
- **Hydrolab MS5 Sonde**
 - 650 ft serial cable for live data
- **Hobby grade autopilot for GPS guided control**



Initial Design (2017) cont'd

- **Custom electronics**
 - All housed in one control box
 - Multiple data and signal cables protruding from the box
- **Wifi communication for reel control**
- **Long range radio control for boat control**
- **On-board cameras for video and audio feedback**



Initial Design (2017) cont'd

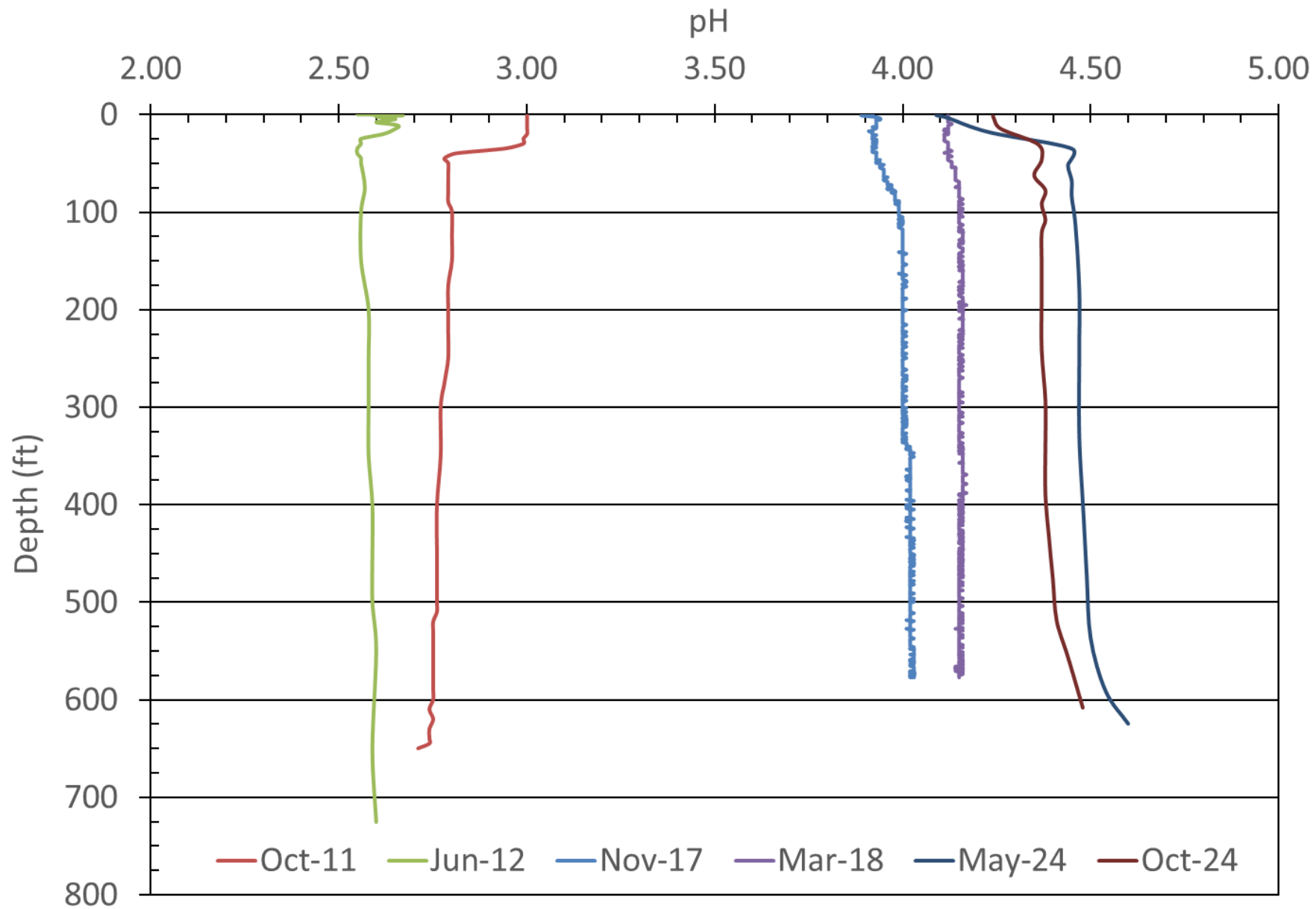


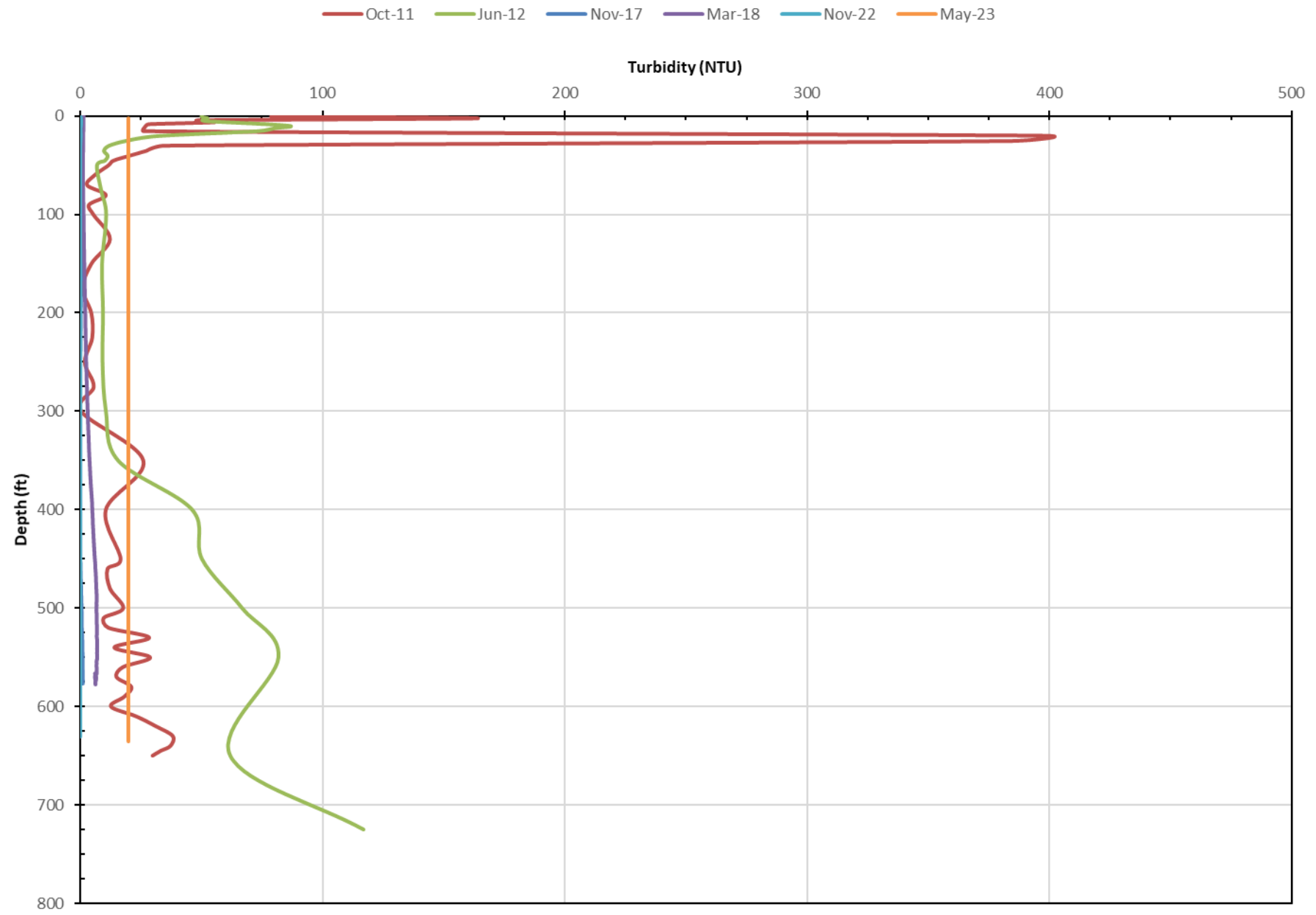
What worked really well

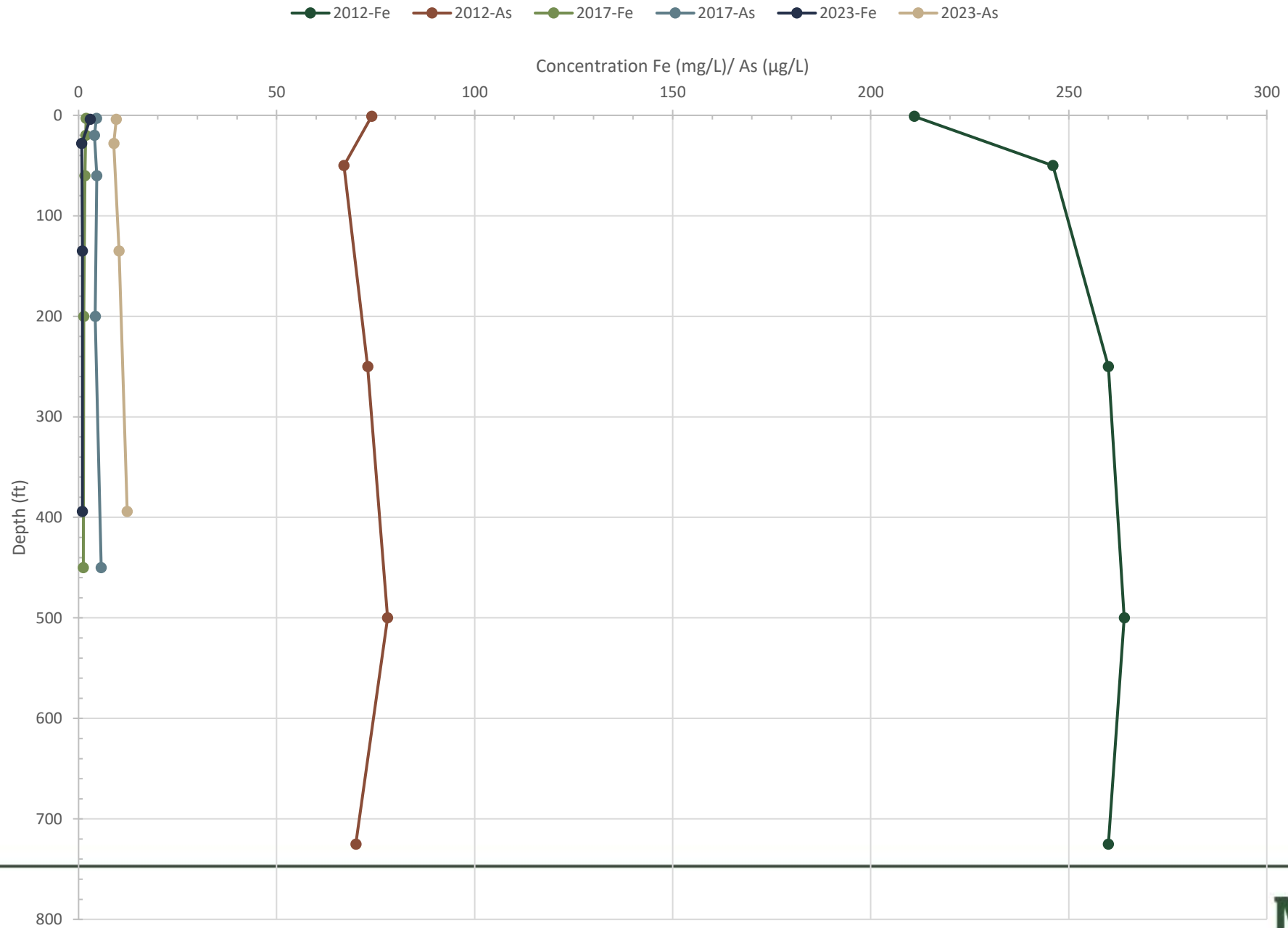
- **Skid steer is a great way to navigate**
- **Long range Wifi is a great way to navigate**
- **The auto pilot worked very well. Allowed for:**
 - Primary manual control (Radio control)
 - Secondary manual control (over wifi)
 - GPS guided waypoints
- **Custom electronics were useful, but poorly implemented**

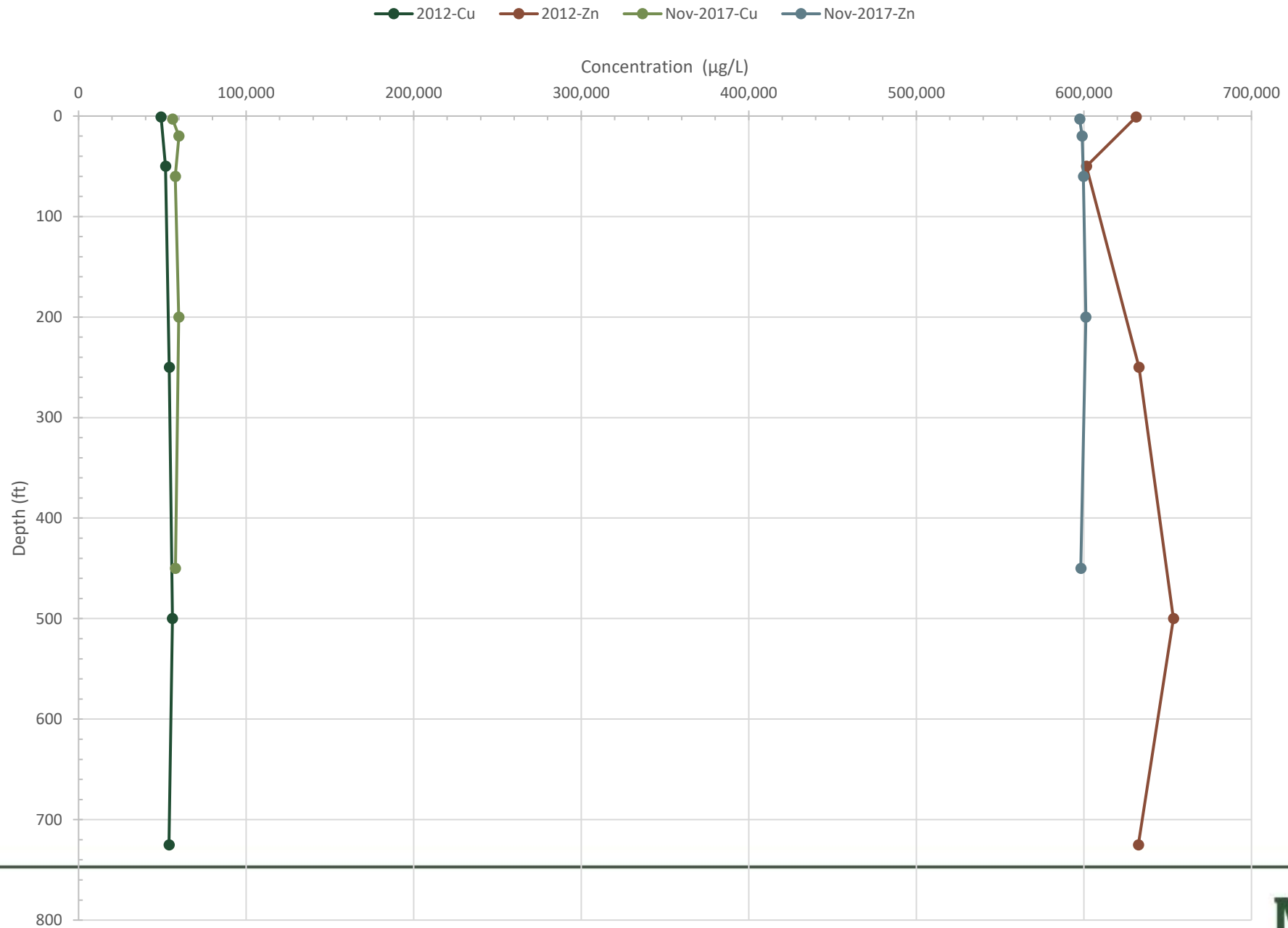
What we learned

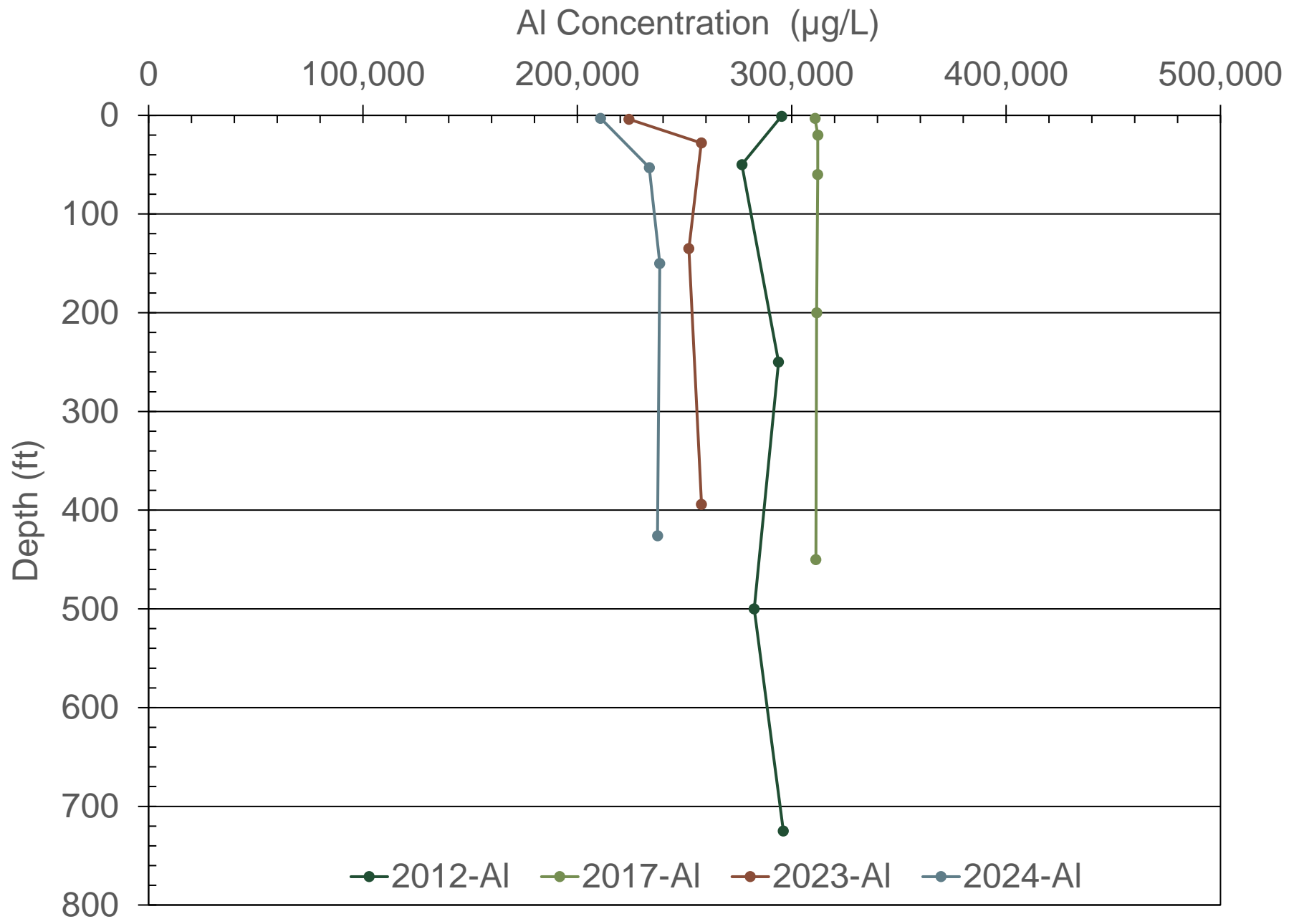
- **All electronics in one box is a problem**
- **The drift boat acts like a big sail in wind**
- **Dead reckoning for the sampler arm leads to sample bottle errors**
- **We need better drive motor controllers for longer missions**
- **Separate batteries for locomotion and sampling is helpful**
- **Wouldn't it be nice to...**
 - Remotely lower the props
 - Have modular electronics
 - Do a bathymetric survey
 - Monitor motor controller temperatures
 - Be able to recover a boat that's stuck
 - Hold the hoses and data cables below the props
 - Raise the hose and sonde above the level of the water

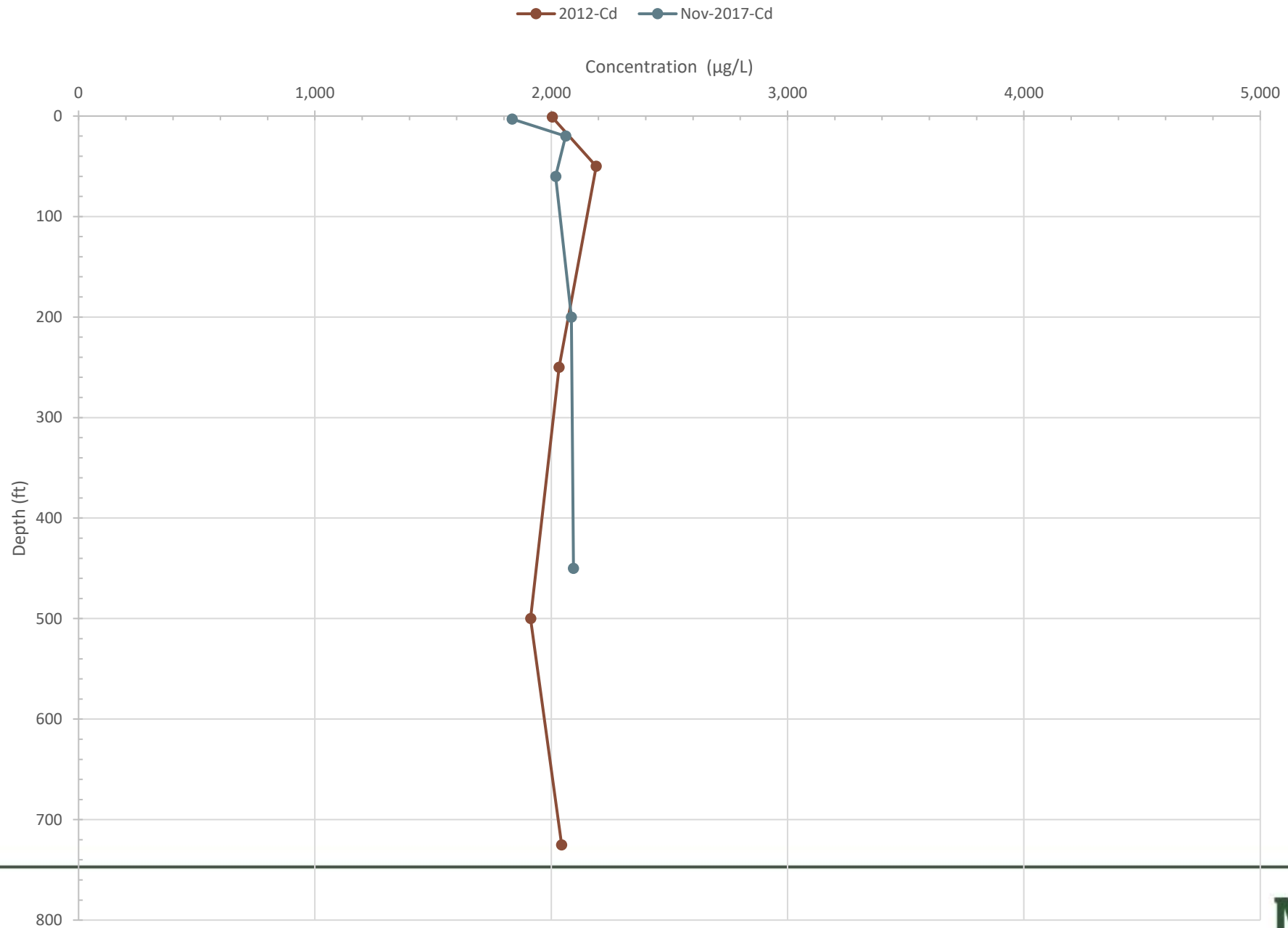






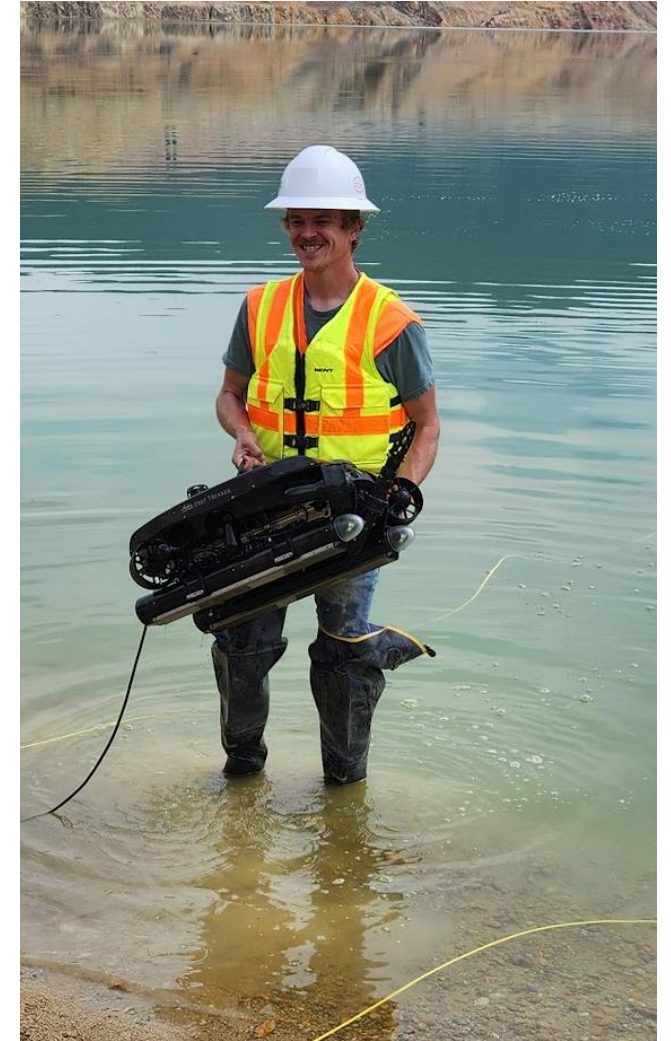


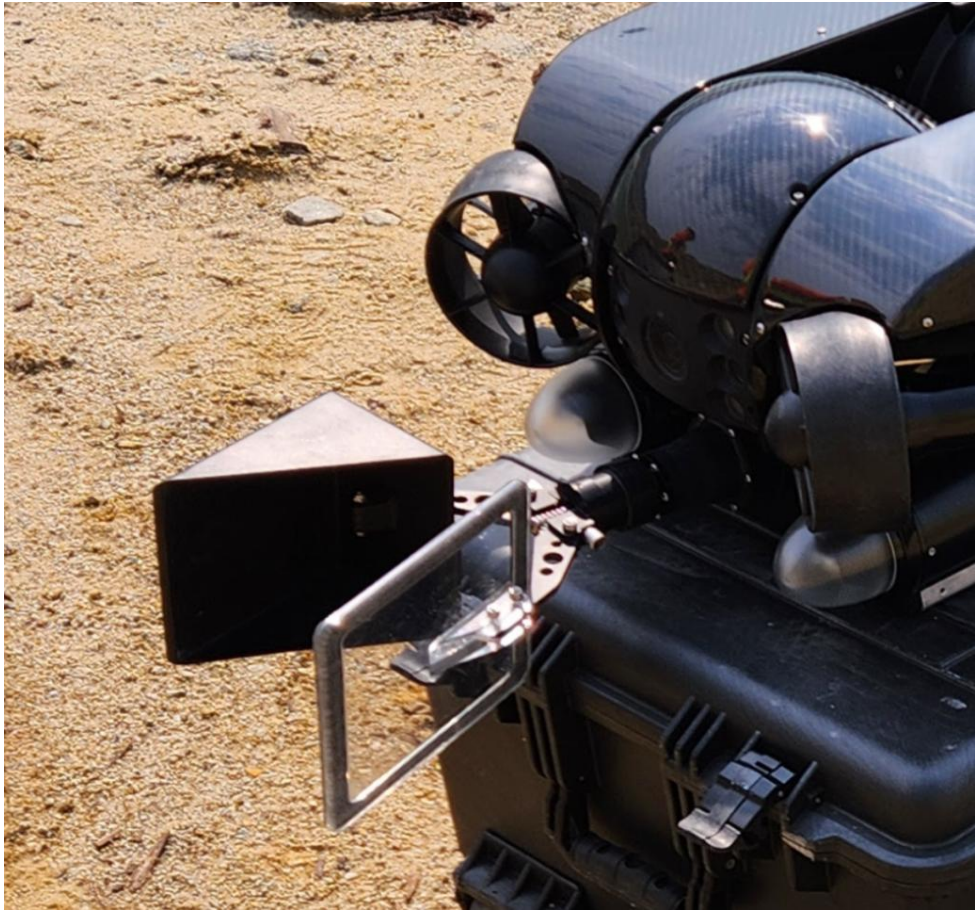


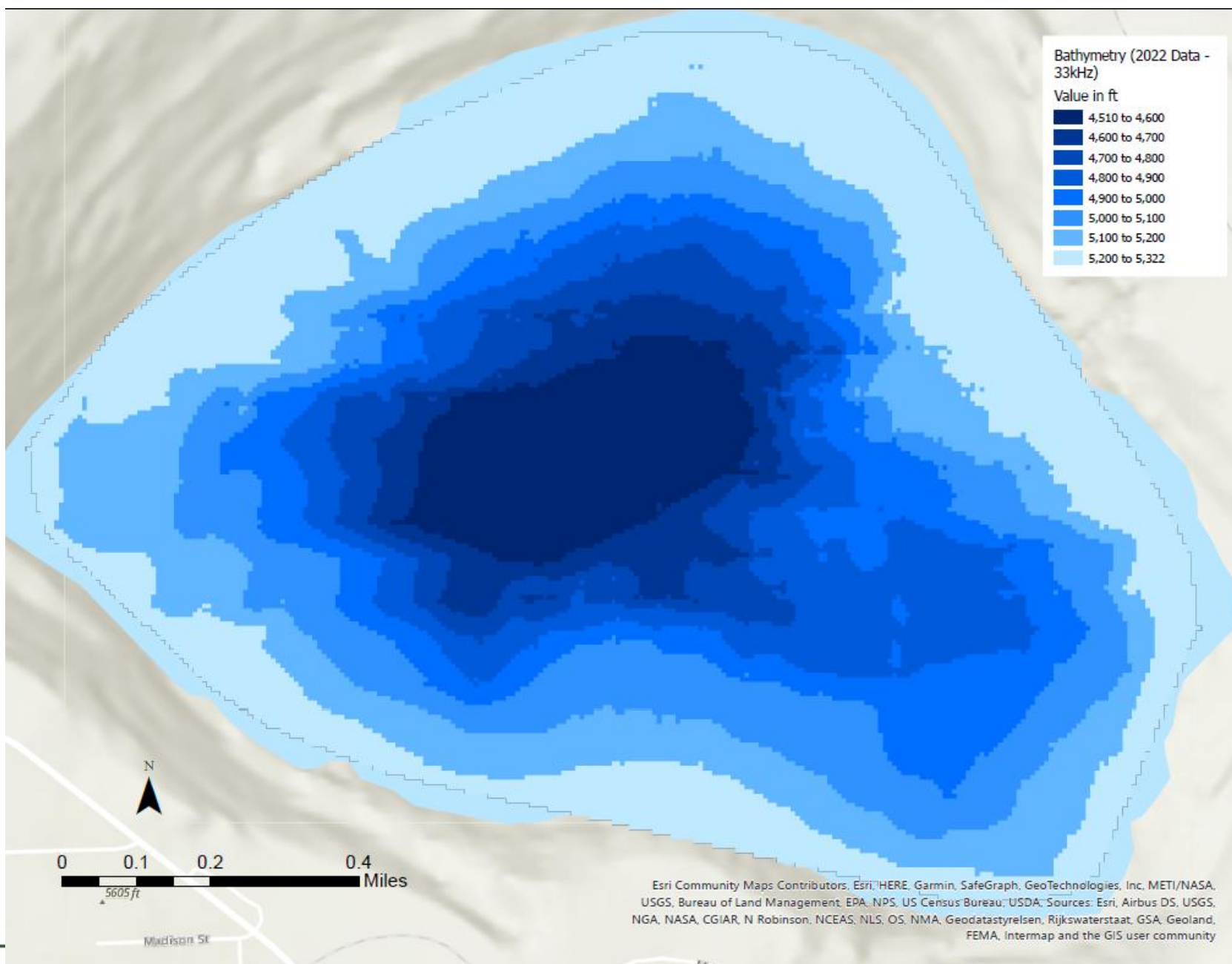


What we've updated

- **Designed and improved remote prop hoist**
- **Added a bathymetric survey system**
- **Added outriggers to control the hose and cable**
- **Re-designed the electronics boards to be modular**
- **Added an absolute encoder on the sampler arm**
- **Placed a control module at each device**
 - Hose reel
 - Data Reel
 - Pump
 - Sampler
 - Brake
 - Navigation
- **Added a Deep Trekker ROV to our fleet (tethered submersible)**

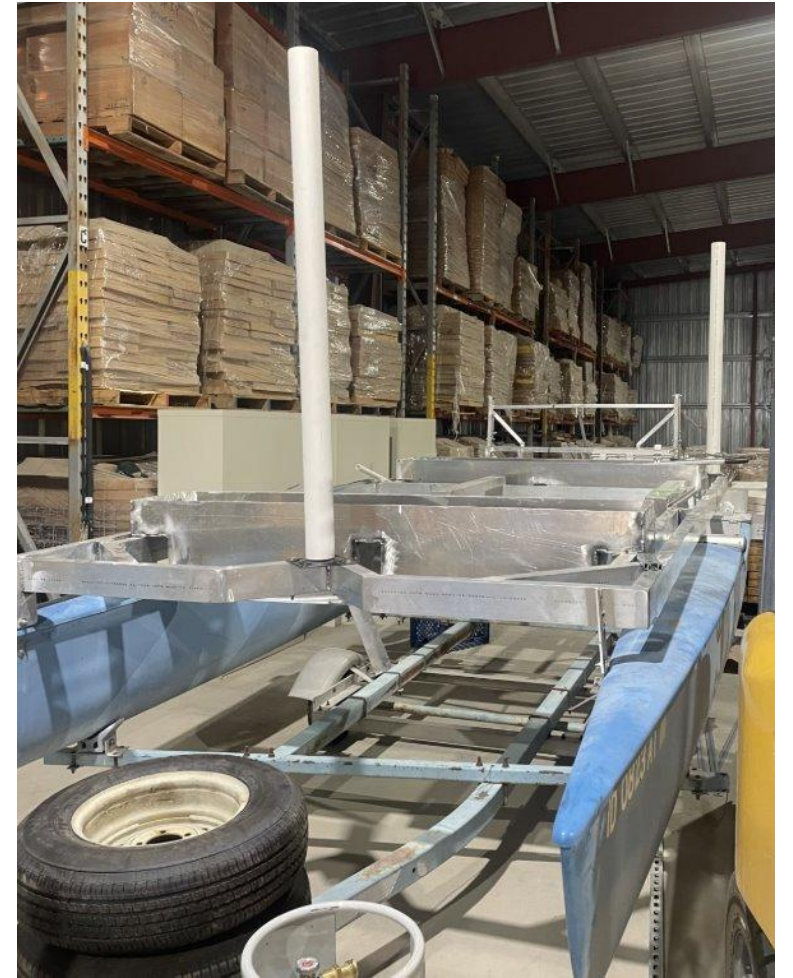






What we want to update

- **Currently building a second boat on a catamaran platform**
 - Adding a reel for sediment sampling (one-shot)
 - Adding a boat recovery system
 - Capability to launch Deep Trekker from the boat allowing for nearly unlimited range of the ROV
 - Update software for more ease of use for sonde data
 - Implement automatic firmware flashing of all devices



What we've gotten really good at

- **Mechanizing reels**
 - Using iterations of the same firmware and hardware for each reel
 - Currently three working reels with a fourth on the way
- **Creating custom electronic hardware**
 - PCB design has improved dramatically
 - Modular design has allowed for quick turnaround on new modules
- **Anticipating remote control issues**

Conclusions

- **Getting to a reliable custom sampling vehicle takes time to make reliable**
- **The boat has become a multi-tool for anything to do with the pit**
- **Decentralize electronics and controls**
- **Rescue options for a remote boat should be made in advance**

Acknowledgements

- Montana Resources
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- Montana Bureau of Mines and Geology



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IS MY OHM BOY



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Questions

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