FloDar

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ABSTRACT

- • Context/Purpose: The purpose of this experiment is to help remotely monitor water flow through collection pipes near roads and highways to identify factors contributing to landslides.
- • Methods: The three variables being collected for the detection of landslides are temperature, turbidity, and water flow rate. Sensors detecting these variables are inserted into a PVC structure that will be placed at the bottom of the current water collection system. All data will be recorded to an SD and eventually transmitted to the web using LoRa.
- • Results: The ultrasonic flowmeter used in the sensing system has show low accuracy (12% to 28% error) when the flow is below 5 LPM but high accuracy (7% to 1%) at flows higher than 7 LPM. The turbidity sensor has shown to have qualitative accuracy, not quantitative (NTU) accuracy. The system has only lasted 8 days in the field so far, but efforts are being made to improve its life.
- • Interpretation: The client is happy with the accuracy of the sensor and finds the sensitivity of the other sensors acceptable. Because the locations where these sensor systems will be implemented will be remote, the length the sensor can be active is very important. The team is working on adding a solar system to improve the life span.
- • Conclusion: Though life in the field should be improved, the low cost and accuracy of the system will already improve research on the subject.

PURPOSE

It has been documented that intense rainfall in areas with a high susceptibility to landslides can trigger the occurrence of landslides. (Hughes and Schulz, 2020) With climate change leading to more extreme weather events it is beneficial to have an early warning system when such extreme events are occurring in such areas. This system - combined with other geological data, such as a location's soil properties and terrain map - can allow for a better understanding of exactly what factors cause a landslide event to occur and help government organizations, such as ODOT, to take measures in rerouting traffic or restoring roads. It is with these premises in mind that the FloDar system has been created. When FloDar is implemented in drainage pipes at study areas, researchers can better understand how water flow, temperature, and turbidity within the collected water can affect the occurrence of a landslide. FloDar uses sensors specifically tailored to these variables to record the sensor values in time-intervals of 15 minutes, and eventually be able to transmit this data from remote locations using LoRa. This data can help researchers and government organizations to develop a monitoring database for various locations that may work as an early detection system, alerting authorities of the specific time and the current state of the area when an event occurs.

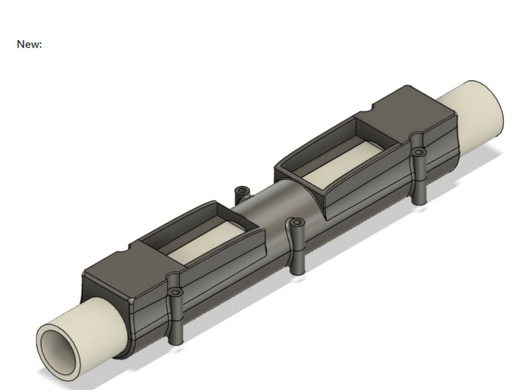

Figure 1: New Transducer Holder

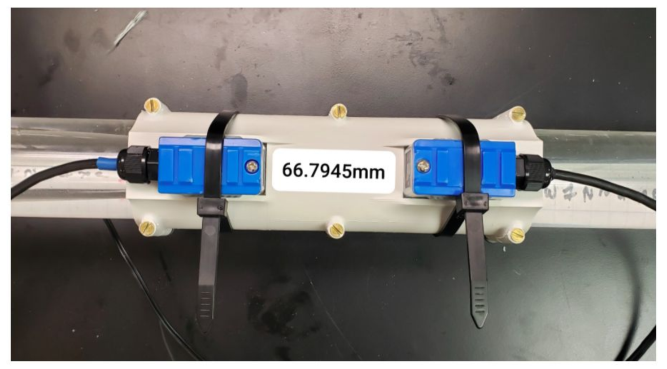

Figure 2: Example of Installed Transducers

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Website/Projects: (http://www.open-sensing.org/)

COMPONENT BREAKDOWN

DFRobot GRAVITY: ANALOG TURBIDITY SENSOR – Measuring Turbidity

TUF-2000M VTSYIQI Ultrasonic Flow Meter – Measuring Flow

Thermocouple Amplifier MAX31856 & Steel Tip Type-K – Measuring Temperature

OPEnS Hypnos Board – Timing, Power Supply Controller, SD Card & Recording

Arduino LoRa Feather M0 – Microcontroller

TalentCell Rechargeable 12V 6000mAh/5V 12000mAh – Power Supply

Newpowa 20W Monocrystalline Solar Panel & Morningstar SunSaver Controller – Battery Recharge

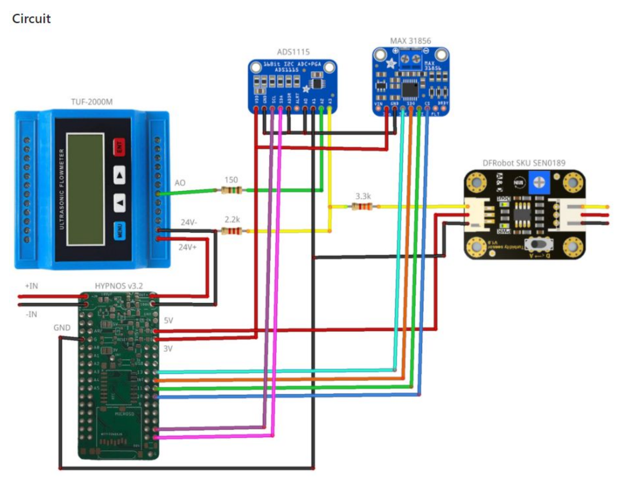

Figure 3: Electrical Components and Circuit

METHODS

When creating the FloDar system, it was necessary to accommodate the collection piping within the field. To do so, a premade PVC pipe section was created with two sub-sections, one specifically for the ultrasonic flowmeter (USFM) and the other for the turbidity sensor and thermocouple. This design was made to ensure that any sub-section can be replaced if maintenance or repair is ever needed. The sections are connected using a PVC screw-on union to ease the process of set-up and replacement. To ensure all components were inserted and no water could escape a waterproof 2-part epoxy was used. Installing the transducers of the USFM can be tedious if only one technician is available, so a 3D printed collar has been created to quicken the process and increase the accuracy of transducer spacing distance.

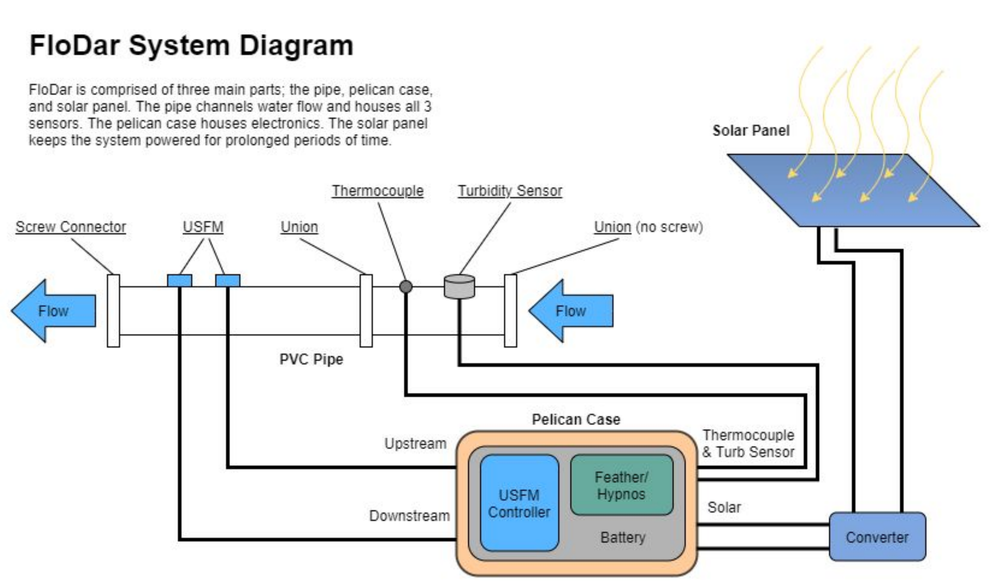

Figure 4: System Design

All electronic components in the FloDar system are powered using the Talent Cell battery and recharged using a 10W solar panel and SunSaver controller. The thermocouple is attached to the MAX31856 for data collection and recording to the Feather M0 while the USFM and turbidity sensor data are recorded using the ADS1115 to improve accuracy. Because each sensor requires a different voltage supply, the OPEnS Hypnos board was selected as it has enough power supply rails to accommodate the project. The Hypnos board also improved the timing of the Feather M0 and allows recording to an SD card, which made its selection perfect for the project. All components are stored in a waterproof Pelican Case to ensure no damage occurs in the field. With proper construction, the researcher can easily take the connected pipe section into the field, insert it into the collection pipe, and place the Pelican case nearby after turning the sensor system on. They can then leave FloDar in the field and come check on it whenever they wish to collect data, taking the time to exchange batteries if necessary.

TESTING

To ensure the Ultrasonic Flowmeter selected for this system would provide accurate results, an experiment was devised to test the percent error in relation to the flow rate within the Calibration System mentioned below. The sensor's technical manual describes a limit to the accuracy associated with low flows, which was also seen in the experiment. However, the experiment also showed that as the flow rate increased the error rate decreased for most trials. Because mean error for the error rate increased between the final two flow settings, the experiment may need to be conducted again with higher flows to see if the error rate is parabolic or if the error rate truly shows a exponential approaching zero.

RESULTS

Testing Methodology:

1. Turn on the pump at 20% of maximum flow rate
2. Wait until all bubbles and air gaps have been removed from system
3. If some gaps will not leave the system, turn the flow rate up to 40% until they leave and then turn back down to 20%
4. Place your 500mL volumetric measuring equipment into the collection basin
5. Turn on USFM
6. Reset your stopwatch to zero
7. With one hand, place outflow tube over your 500mL volumetric measuring equipment, starting the timer immediately
8. Wait until 500mL has been reached then immediately stop the stopwatch
9. Record trial
10. Look at reading on USFM, record trial
11. Turn off USFM
12. Empty 500mL volumetric measuring equipment
13. Repeat steps 3-11 until you have at least 5 trials for flow rate
14. Repeat steps 3-12 for 30%, 40%, 50%, & 60%

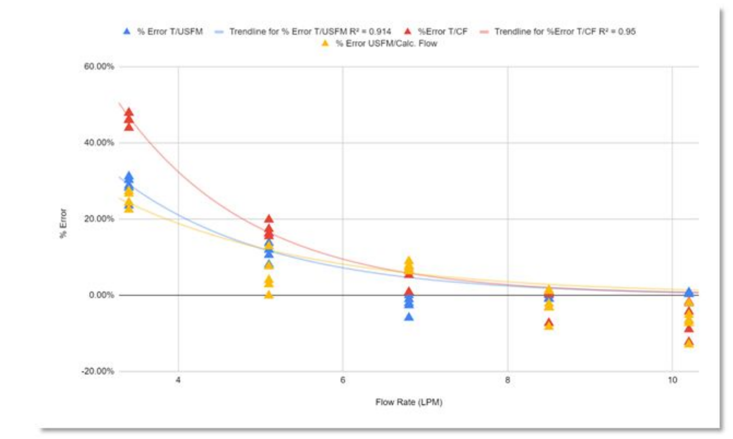

Figure 5: Graph of Accuracy vs. Flow Rate

Theoretical Flow Rate (LPM)	USFM Average Error	USFM Mean Error	USFM 95% Error Confidence Range	Calculate Flow Average Error	Calculate Flow Mean Error	Calculate Flow 95% Error Confidence Range	Difference Average Error	Difference Mean Error	Difference 95% Error Confidence Range
3.4	28.4%	5.8%	(22.6%,34.2%)	46.4%	3.2%	(43.2%,49.6%)	25.0%	3.9%	(21.2%,26.4%)
5.1	12.1%	6.1%	(6%,18.2%)	17.0%	3.4%	(13.6%,20.4%)	5.4%	9.7%	(-4.3%,22.6%)
6.8	-2.0%	4.4%	(-6.7%,2%)	5.1%	5.1%	(.1%,10.2%)	7.3%	2.1%	(5.2%,9.4%)
8.5	-0.3%	1.6%	(-1.9%,1.2%)	-2.6%	6.3%	(-8.8%,3.7%)	-2.2%	7.7%	(-10%,-.6%)
10.2	0.0%	2.4%	(-2.4%,2.5%)	-6.8%	8.0%	(-14.7%,1.2%)	-6.8%	7.8%	(-14.6%,1.1%)

Table 1: REsults of Accuracy vs. Flow Rate Test

CONCLUSIONS: FUTURE DIRECTION

As climate change progresses and extreme weather events begin to occur more frequently a better understanding of the effect precipitation can have on landslides is necessary. It is hoped that the FloDar system can help researchers and government organizations record data from various locations, especially remote areas, that will allow for this understanding. So far, the system has shown great promise in its ability to accurately measure flow and give some insight to the turbidity and temperature within the collection system. Though more long-term testing is necessary and there is room for improvement for the lifetime of FloDar out in the field, we look forward to seeing how we can make the project better in the coming months.

ACKNOWLEDGMENTS

This project would not have been possible without funding and insight given by the OSU Forestry Department Professor, Dr. Ben Leschinsky, and his graduate student, Mahrooz Abed. This funding was provided in connection with Oregon Department of Transportation, so the FloDar team is extremely grateful for the opportunity to receive these resources. All Professors in the OPEnS Lab have been instrumental in designing and testing the FloDar system, with Dr. Chet Udell providing the initial components, circuitry, and direction while Cara Walter, PE and Dr. John Selker have ensured all piping and flow parameters have been accounted for in the design. Though he is no longer working directly on the project, Hadi Abdulameer Jasim Al-Agele helped a great deal initializing the project, creating the prototype for the transducer collar and helping Andrew Walker become acclimated to the lab.

We would also be remiss if we did not thank the many lab members that gave advice and oversight while creating the many sub-designs throughout the project. Without the Loom Team, we would not have been able to make the software as easily or quickly; without Bao Nguyen, we would not have had to do much research to create the proper circuitry for the project; and without the support of the rest of the teams in the lab we would have missed essential feedback and new ideas that helped refine the project over time.