A Feasibility Study for the Automated Monitoring and Control of Mine Water Discharges

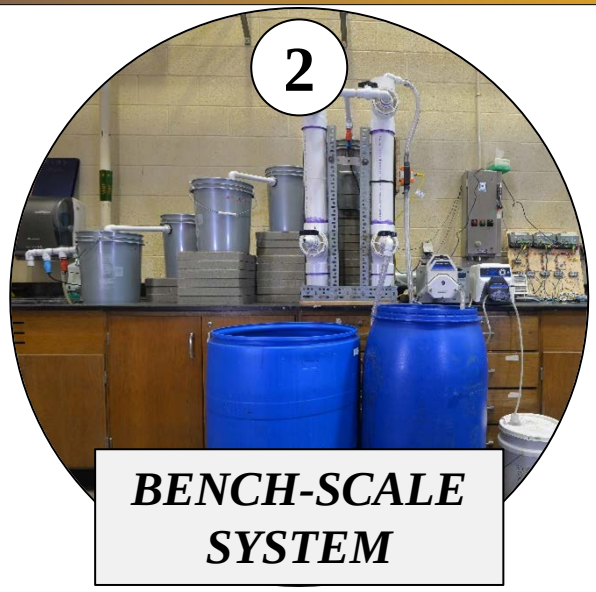
2017 WV Mine Drainage Taskforce

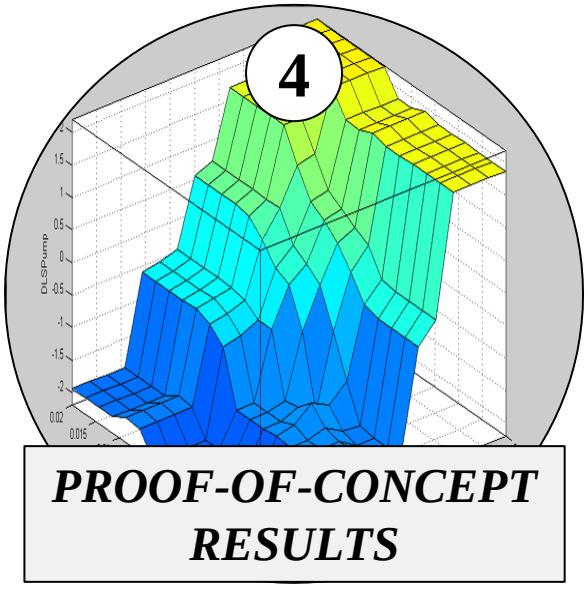
Chris Vass
Aaron Noble, PhD
Mining Engineering
West Virginia University

Morgantown, WV
April 11, 2017

WestVirginiaUniversity.
BENJAMIN M. STATLER COLLEGE OF
ENGINEERING AND MINERAL RESOURCES

Presentation Outline





Automated Outlet Treatment

MOTIVATION

Challenges in CAPP

Remote Locations

No Utilities

Area/Access Limited by Topography

Several parameter limits: pH TSS, Fe, Al, Mn, etc.

Lab Results Take Time

Traditional Practices in CAPP

Rob

Not an environmental chemist, but knows practical water treatment.

Can get to the remote locations, but takes time.

May make it to problematic sites once or twice per day.

Not available 24/7/365.

Will eventually retire or find another job.

Research Objectives

Problem Statements:

- Given the unique environmental challenges in CAPP, traditional methods of water monitoring and treatment are costly and inefficient.
- The current and future regulatory trajectory may deem many of these practices cost prohibitive.

Research Objectives:

- Evaluate the technical and economic feasibility of automated monitoring and advanced control algorithms for chemical treatment of mine water discharges

Generic pH Control Diagram

Process Disturbances:
-Incoming pH
-Flow Rate
-Atmospheric Conditions

Generic Controller

Control Algorithm

Treatment Flow Rate

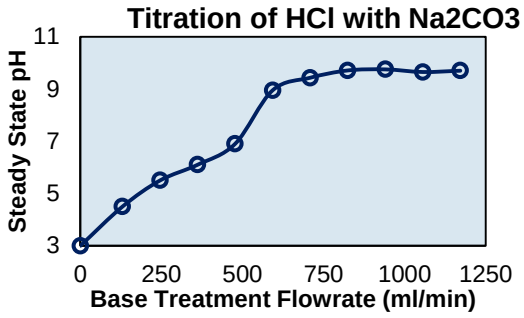
AMD Treatment System

Current System Conditions

Outlet pH

Process Set Point (pH = 7)

Problem: pH Treatment is Nonlinear!

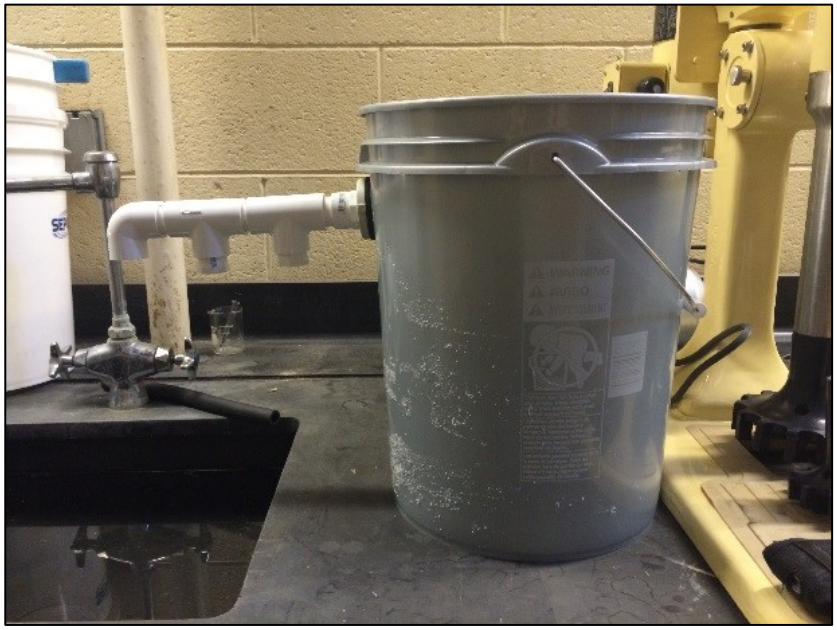


Automated Outlet Treatment

BENCH-SCALE SYSTEM CONSTRUCTION

Components

Reactor

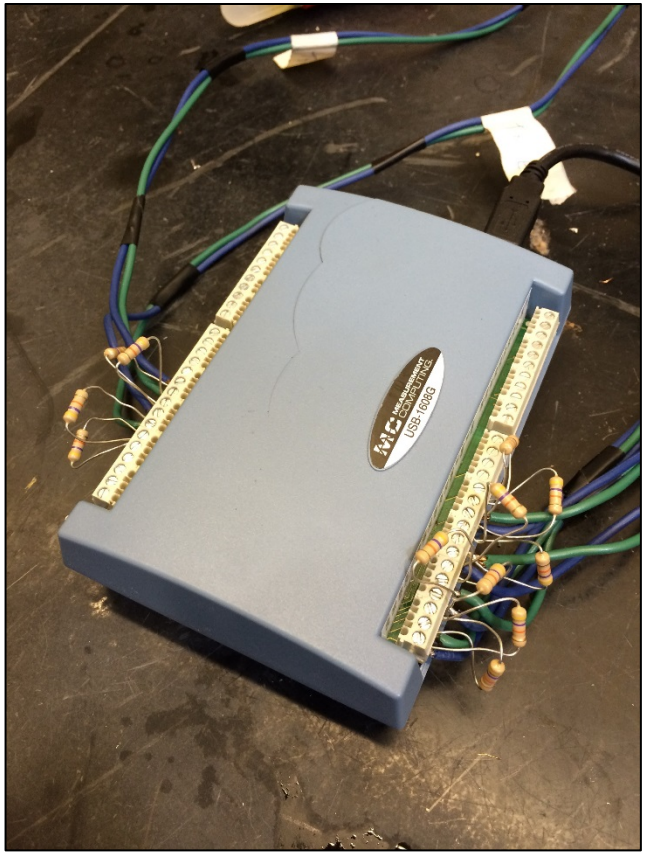


Conductivity Sensor

pH Sensor

Components

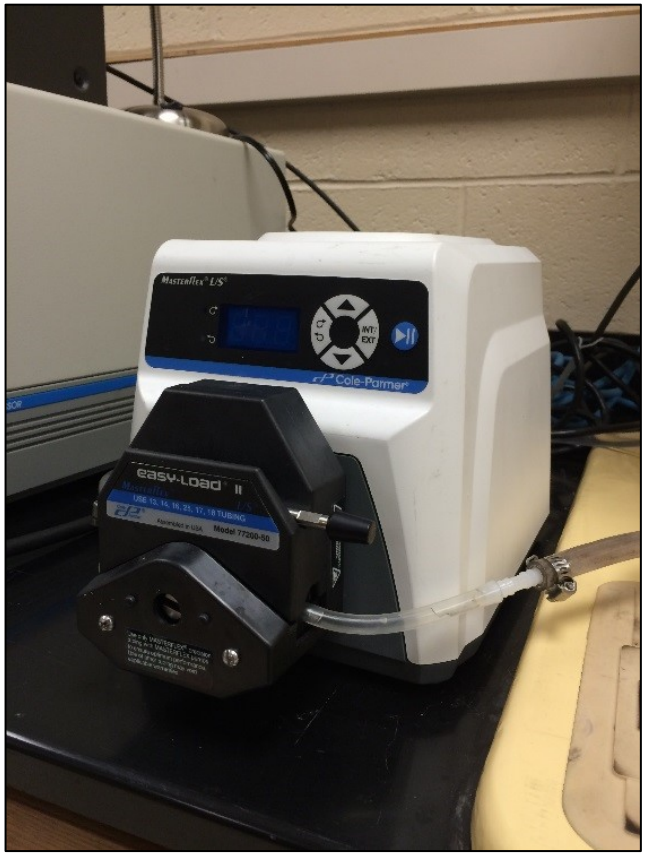
Transmitters/Power Supply



DAQ Unit

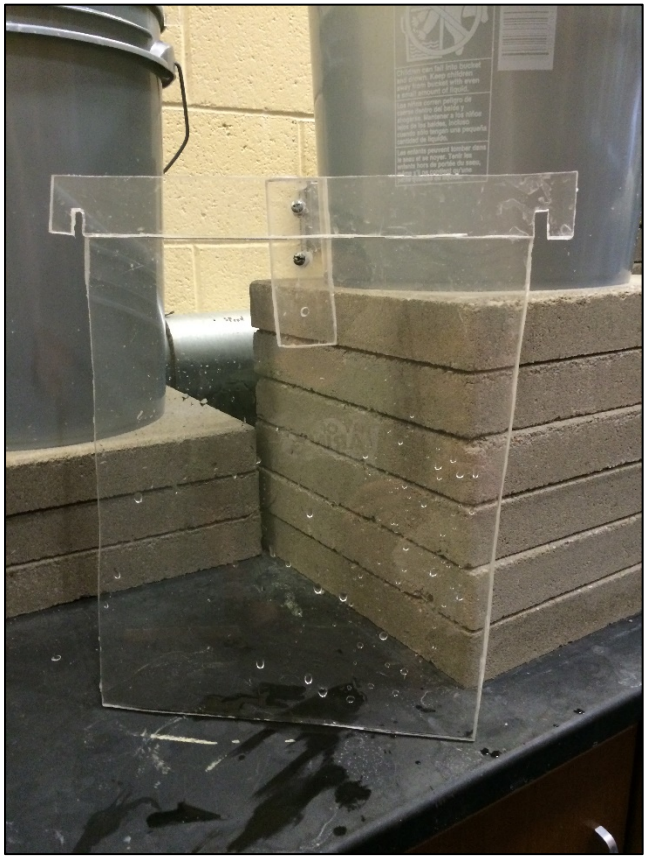
Components

Supply Pump

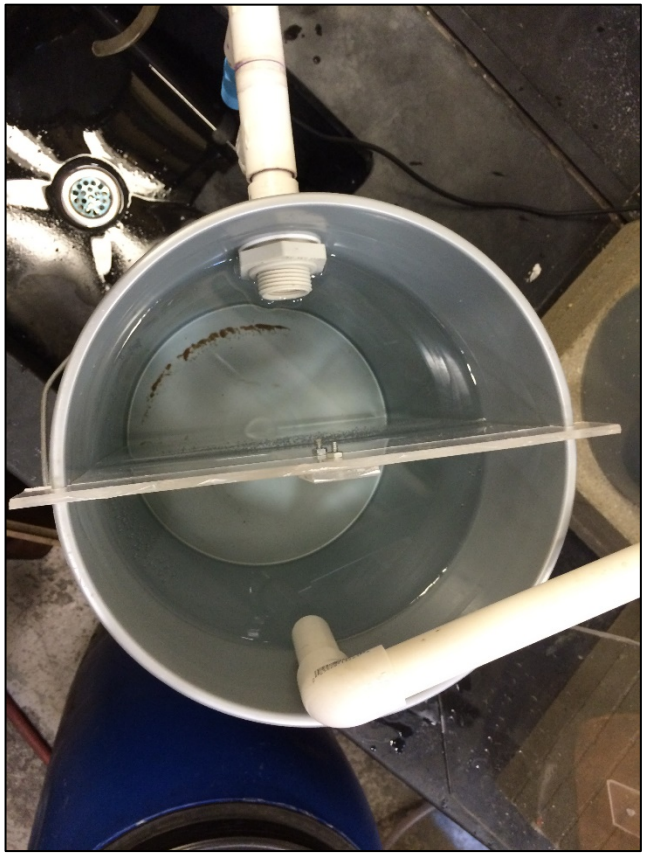


Treatment Pump

Components

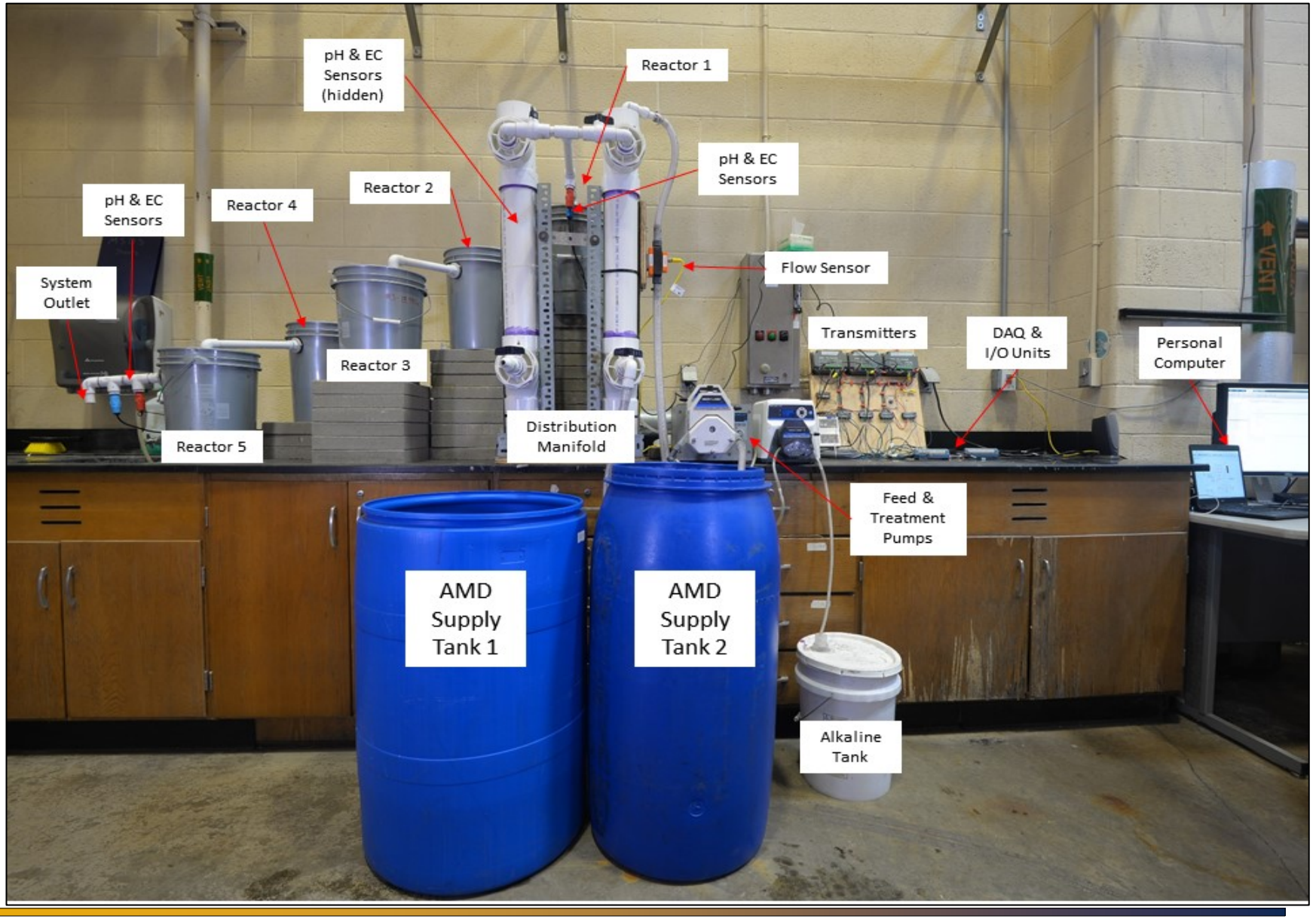


Baffle



Installed Baffle

Bench Scale Model



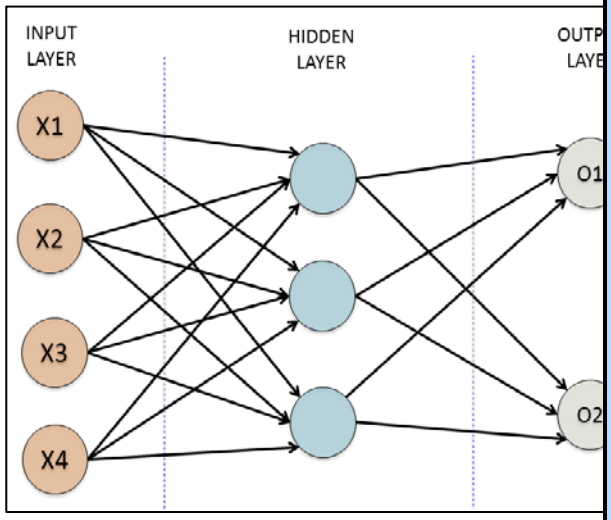
Automated Outlet Treatment

MAMDANI FUZZY CONTROLLER

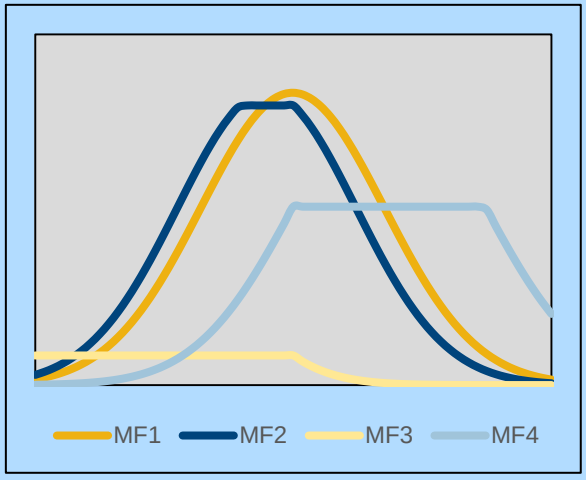
Advanced Control Techniques

Several advanced pH control techniques exist; however, they are currently unproven in a mine environmental setting.

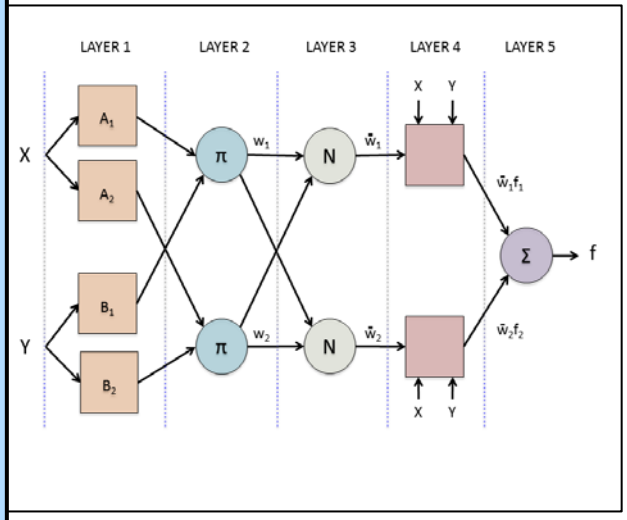
ANN's



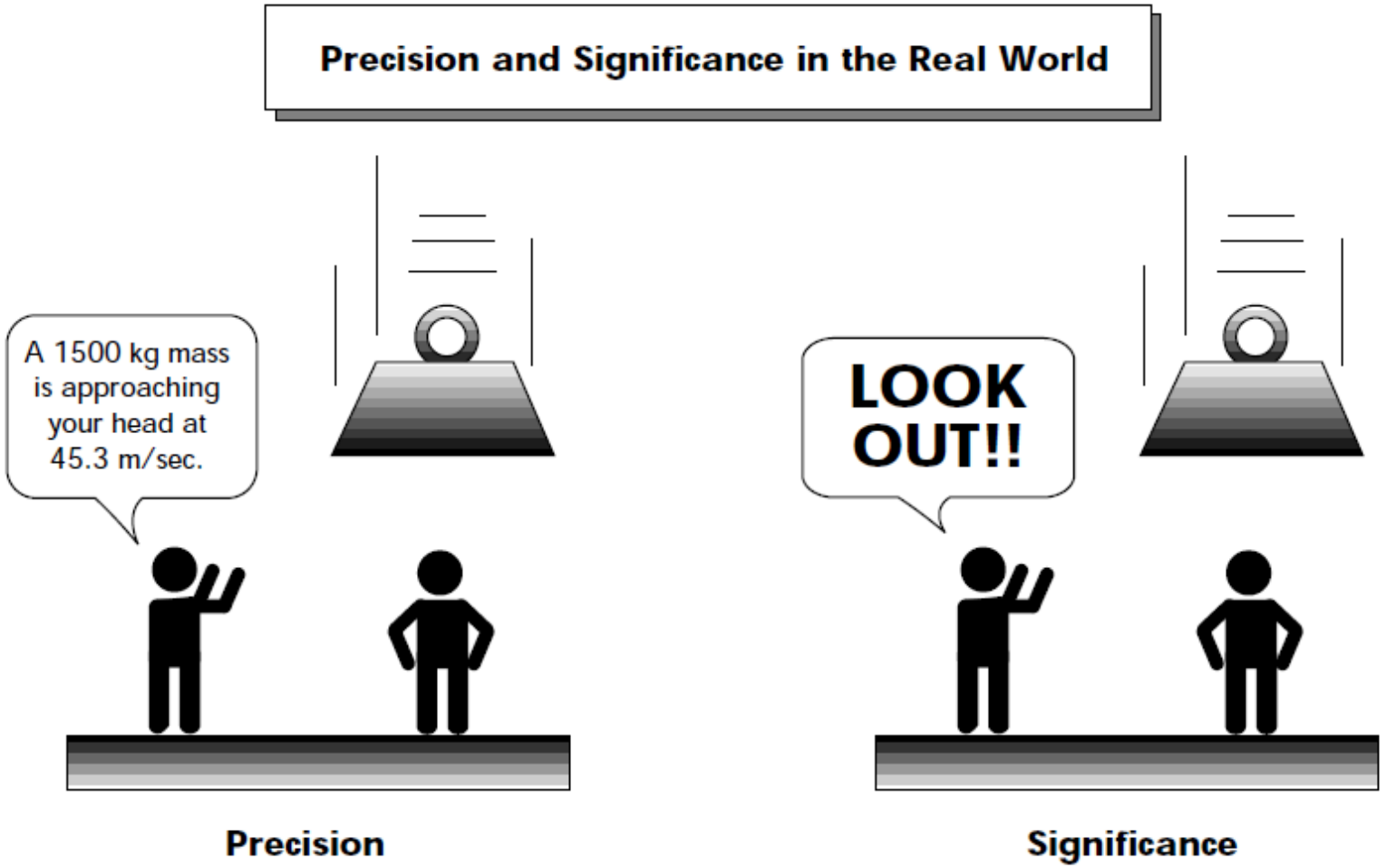
Fuzzy Logic



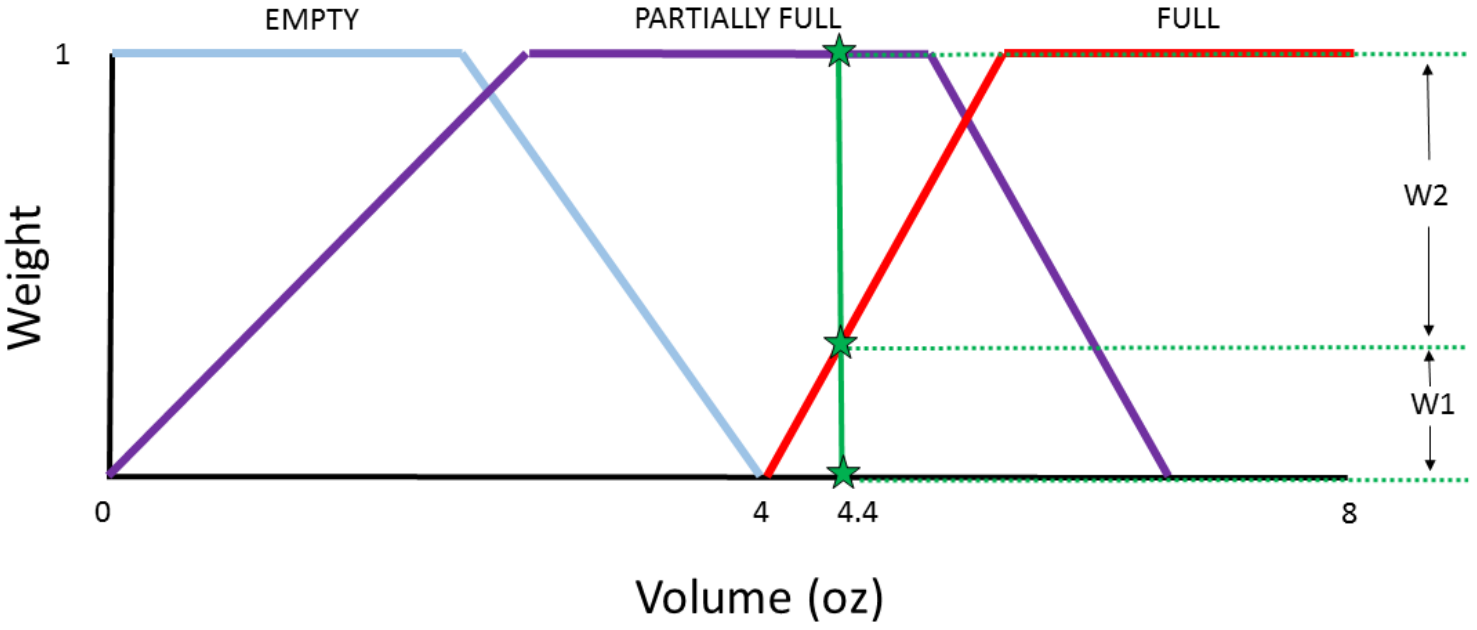
ANFIS



Modeling Approach

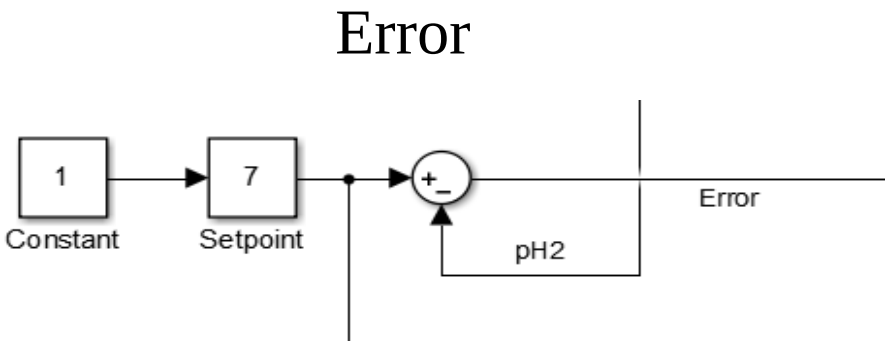


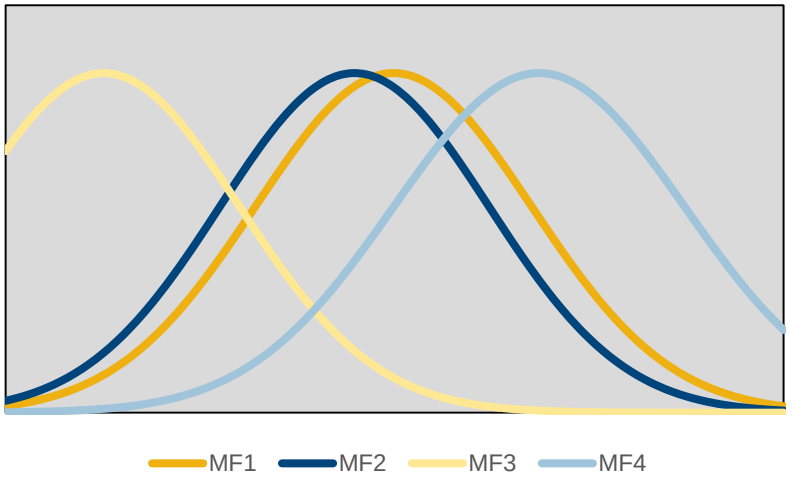
Fuzzy Logic - Basics

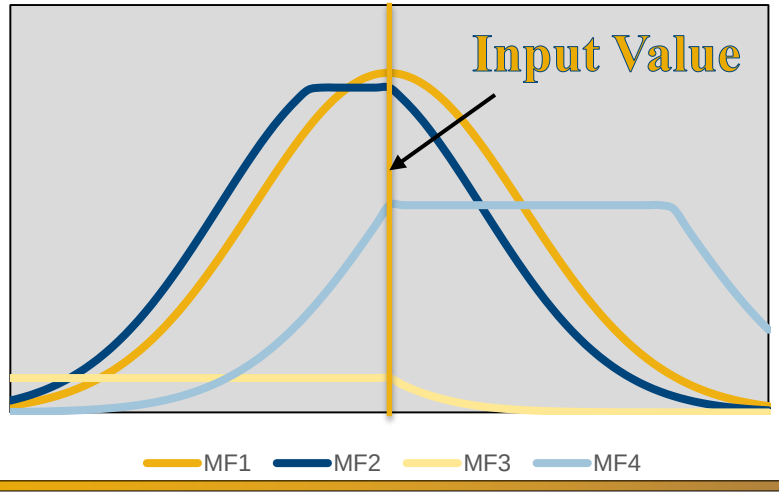


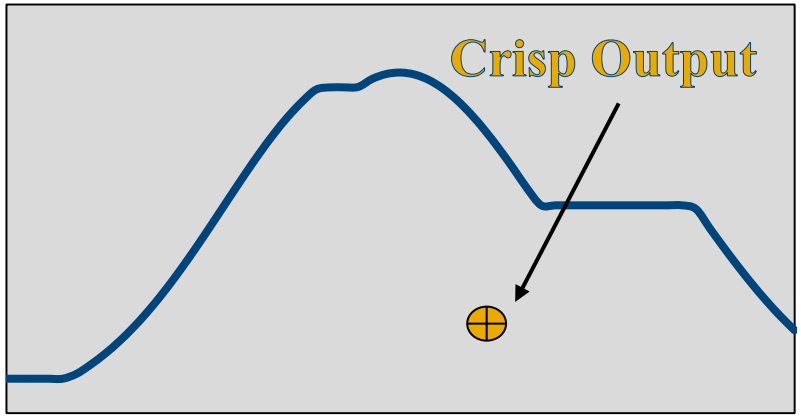
Fuzzy Logic – Membership Functions

- Use of non-precise classes to segment process behavior

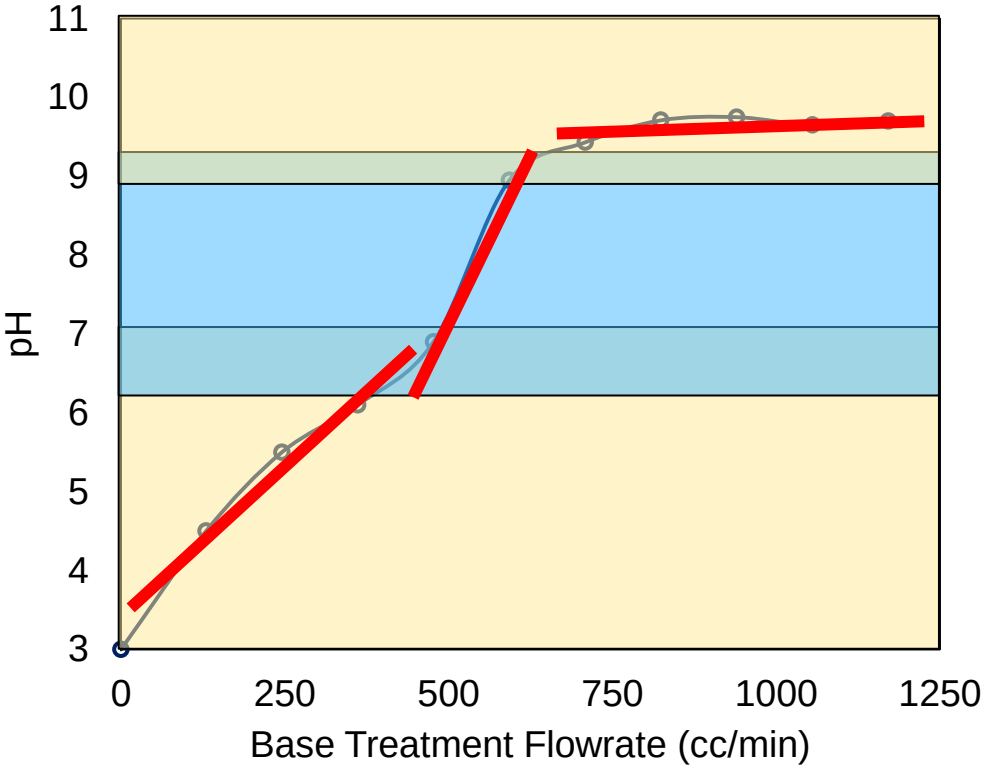


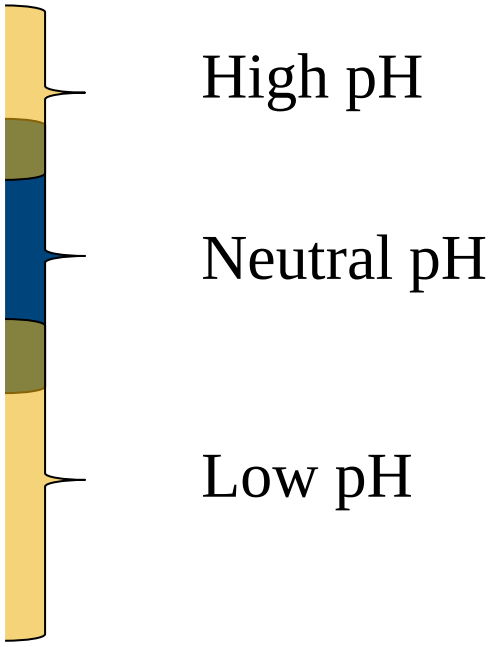




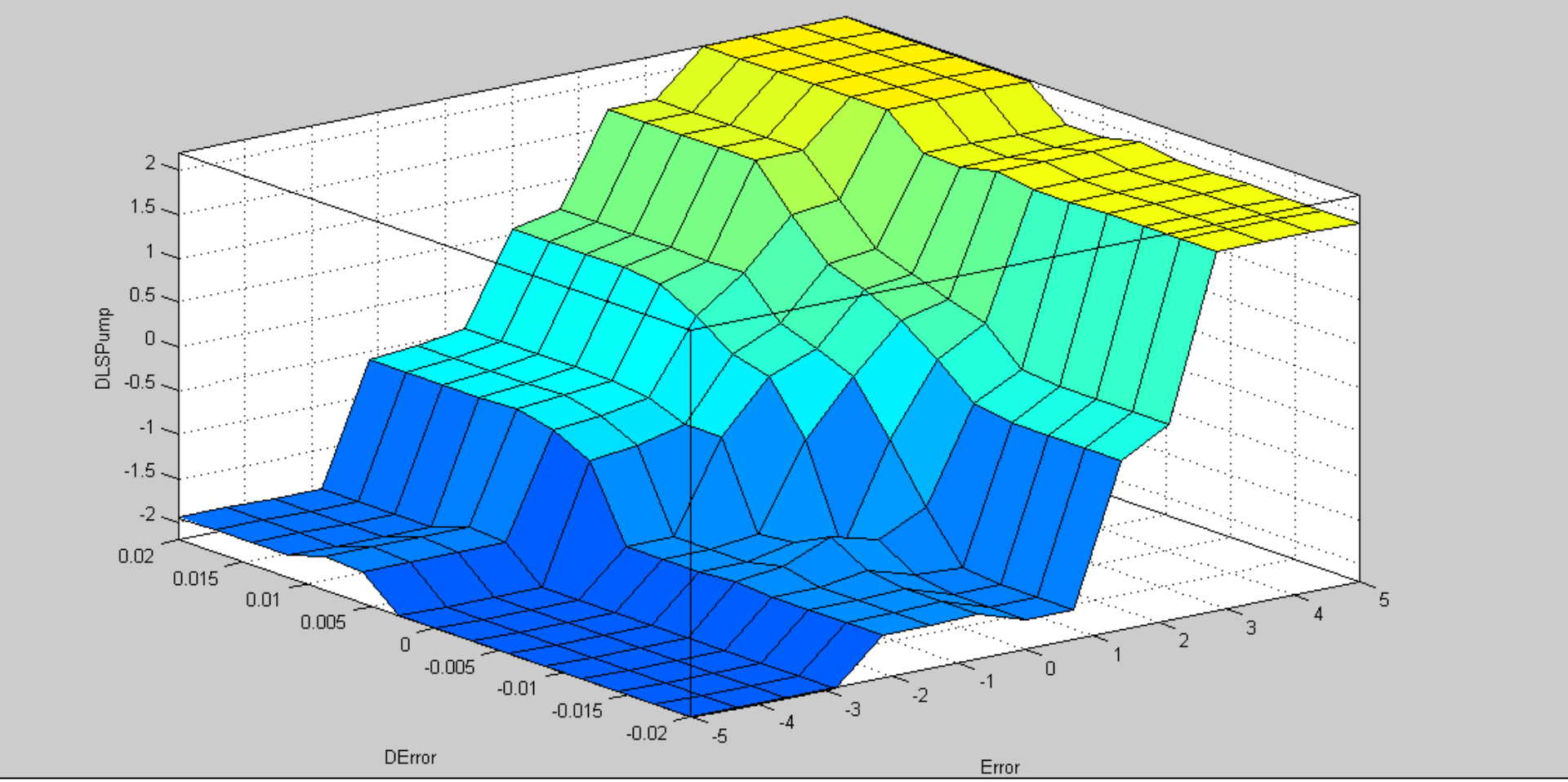


Membership Functions





Doesn't neglect "Rob's" intuition, 30+ years of AMD research, or the real-time data…



Automated Outlet Treatment

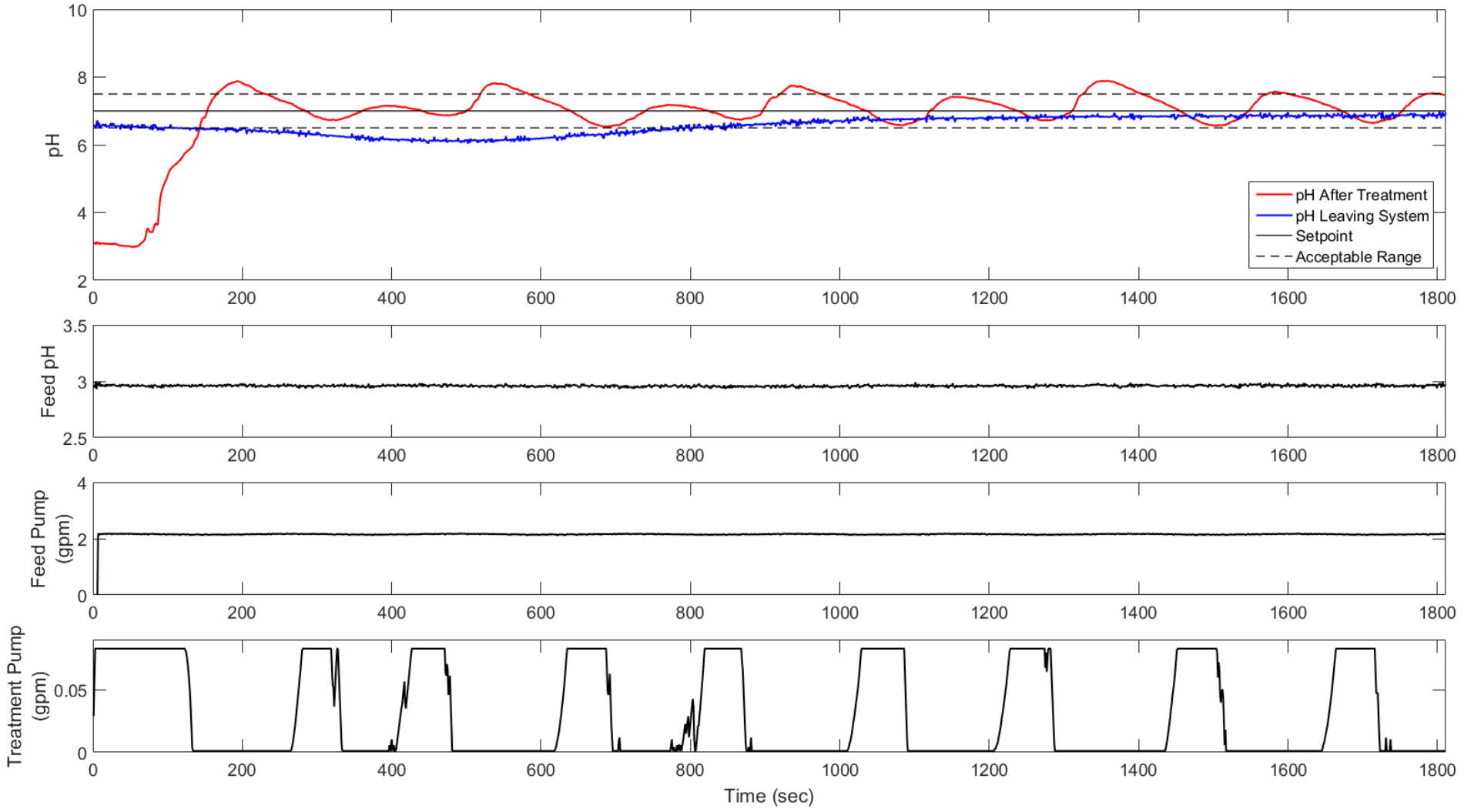
RESULTS & DISCUSSION

pH Control – Experimental Tests

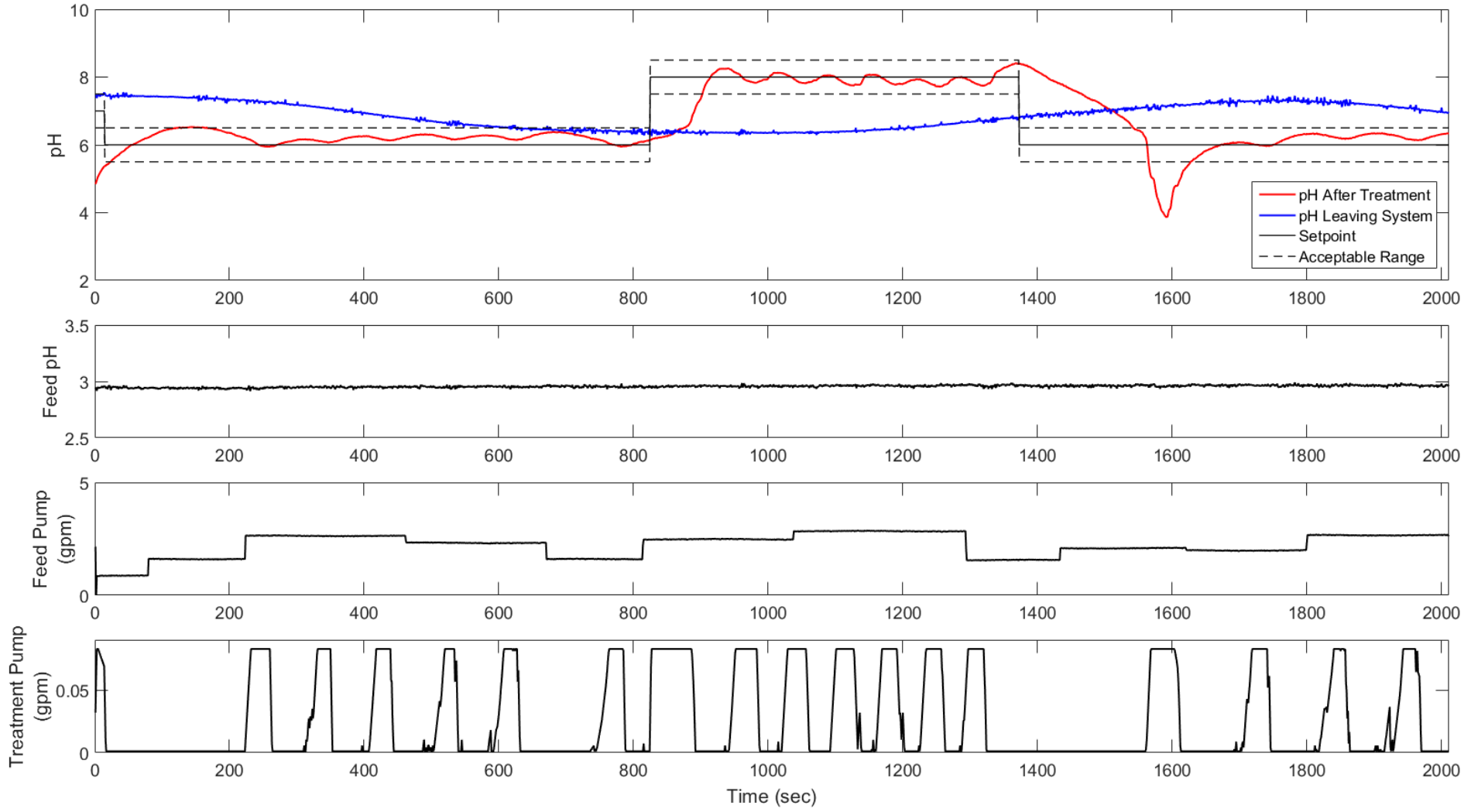
Test No.	Simulated Condition	
1	Normal field Operations under steady state conditions	⟸
2	Unsteady flow rate	
3	Changing pH set point	⟸
4	Large surge in flow rate that interrupts flow recording device	
5	Change in feed water pH	⟸
6	Removal of pond baffle	
7	Multiple disturbances/perturbations	

Define acceptable range as ±0.5 pH point.

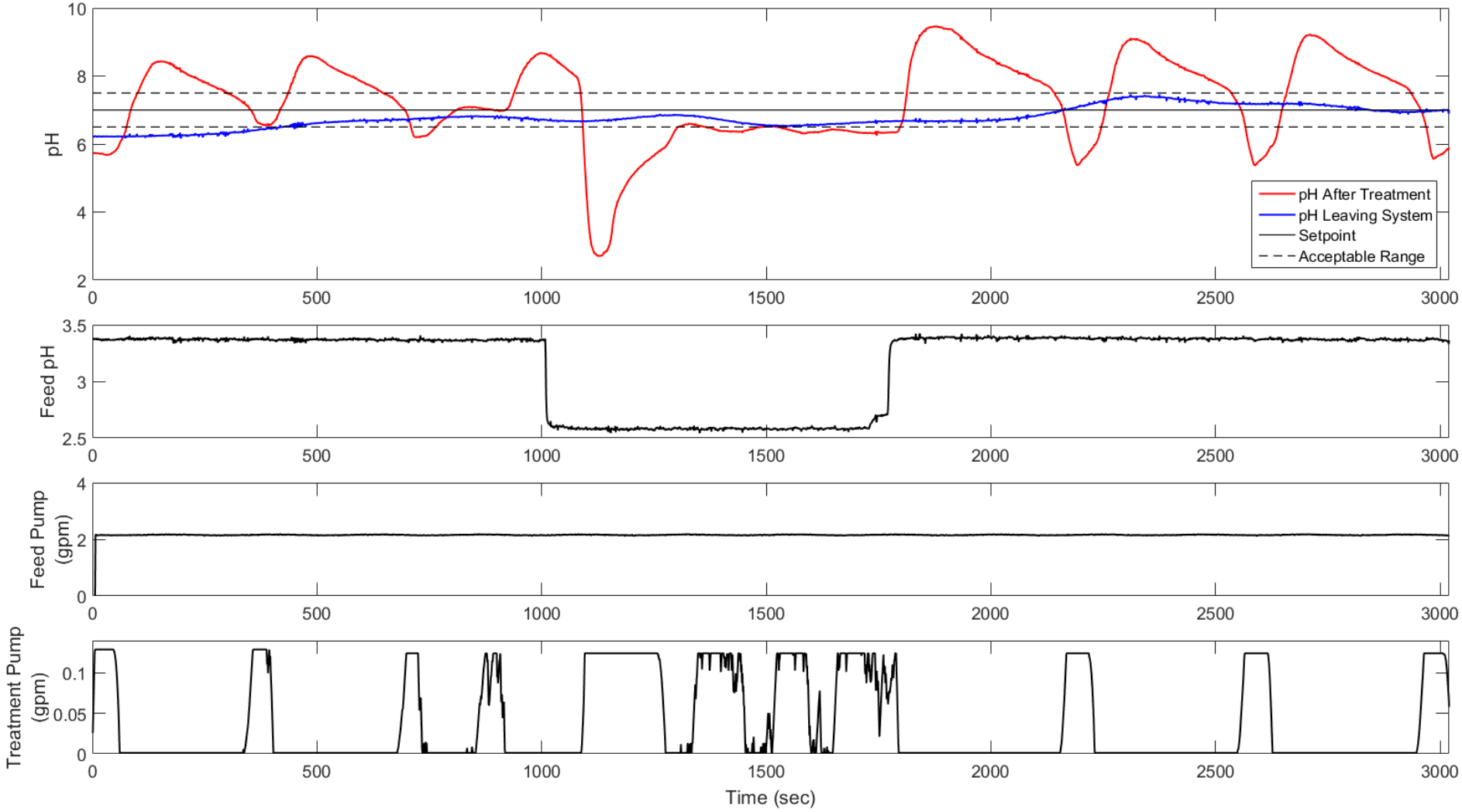
pH Control – Steady State



pH Control – Varying Flow Rates & Set Point



pH Control – Change in Feed pH



Automated Outlet Treatment

ONGOING WORK & CONCLUSIONS

Ongoing Work

- Implementation of control scheme at AMD treatment site

Summary & Conclusions

- Environmental monitoring and treatment costs can be significant and require perpetual attention.
- Laboratory tests have shown that fuzzy logic is a feasible control option.
- The controller used in this testing was able to withstand multiple perturbations and maintain pH within ±0.5.

Questions?

For more information, please contact:

Chris Vass

crvass@mix.wvu.edu

Acknowledgements:

ARIDEA SOLUTIONS

dep
west virginia department of environmental protection