

BACKGROUND & OBJECTIVE

Water With Blessings is an organization that provides point-of-use filtration to mothers and their children across the globe, aiming to provide clean drinking water to vulnerable populations like these. Team 03, composed of four civil engineering students and one electrical engineering student, designed a rainwater collection, storage, and purification system with automated cleaning of the water filter. Success for Team 03 is to provide a design for Water With Blessings to use in the future if needed. Team 03's goal is to partner with the mission of Water With Blessings and work towards implementing stewardship of resources into the design. Team 03's design is constrained by the dimensions of Calvin's Engineering Building and by using Grand Rapids rain data and building code.



PHYSICAL MODELS

Team 03 ordered and assembled all parts to build the backflushing system, including the 10-inch Sawyer filter. This was an original design from Water With Blessings implemented at a hospital in Honduras (see Figure 6). All the electrical components were placed in a constructed wooden enclosure box for safety (see Figure 7).



Figure 6: Designed backflushing system with the 10-inch Sawyer Filter

DESIGN DECISIONS & FINAL DESIGN

Team 03's design is split into three major design categories: water, structural, and electrical (see Figure 1). All design categories have major designs that are interconnected to one another. For the water, or hydraulic, design, the team chose a 10-inch Sawyer filter because of their 0.1-micron absolute filter that exceeds EPA standards, and because Water With Blessings had been partnered with Sawyer for several years already.

The other components of the water design include gutter design, the first-flush system, PVC piping and connections, valves, and adapters. The components of structural include pipe supports to reduce deflection and a tower to elevate the tank to provide enough pressure for the system. Finally, the components to automate the backflushing include Solenoid valves, a power supply, an Arduino microcontroller, and a circuit board.

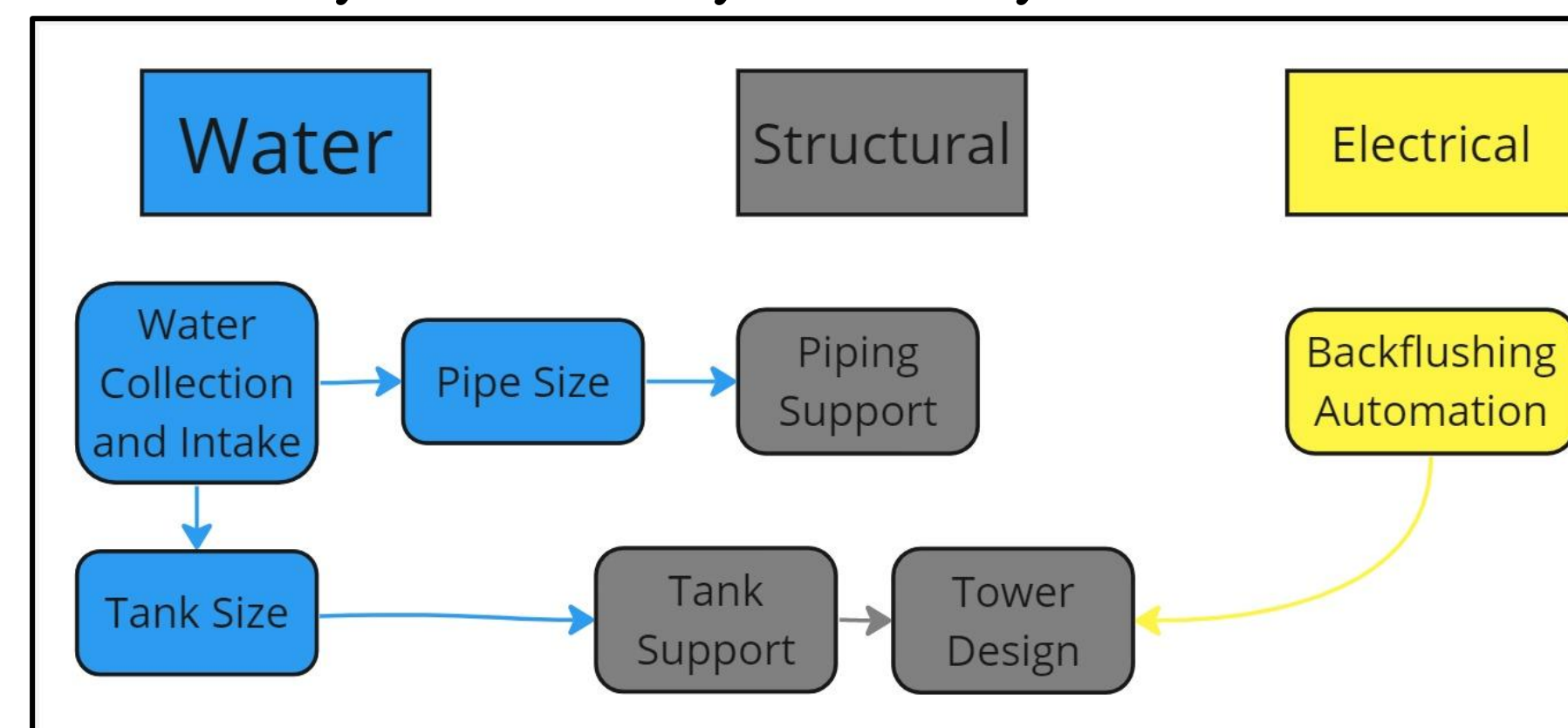


Figure 1: Flow chart of all design sections

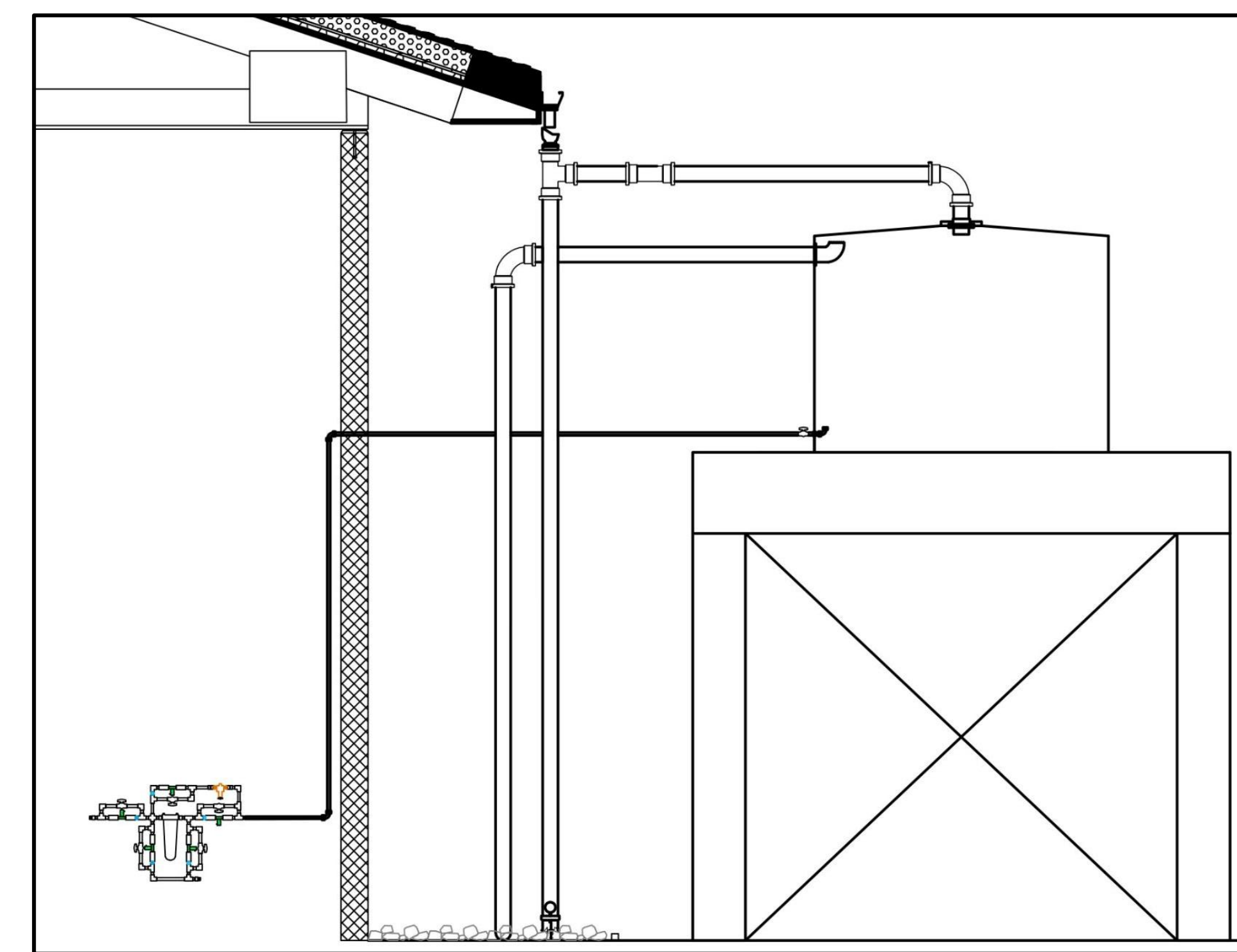


Figure 2: Proposed Design (Southview of Engineering Building)

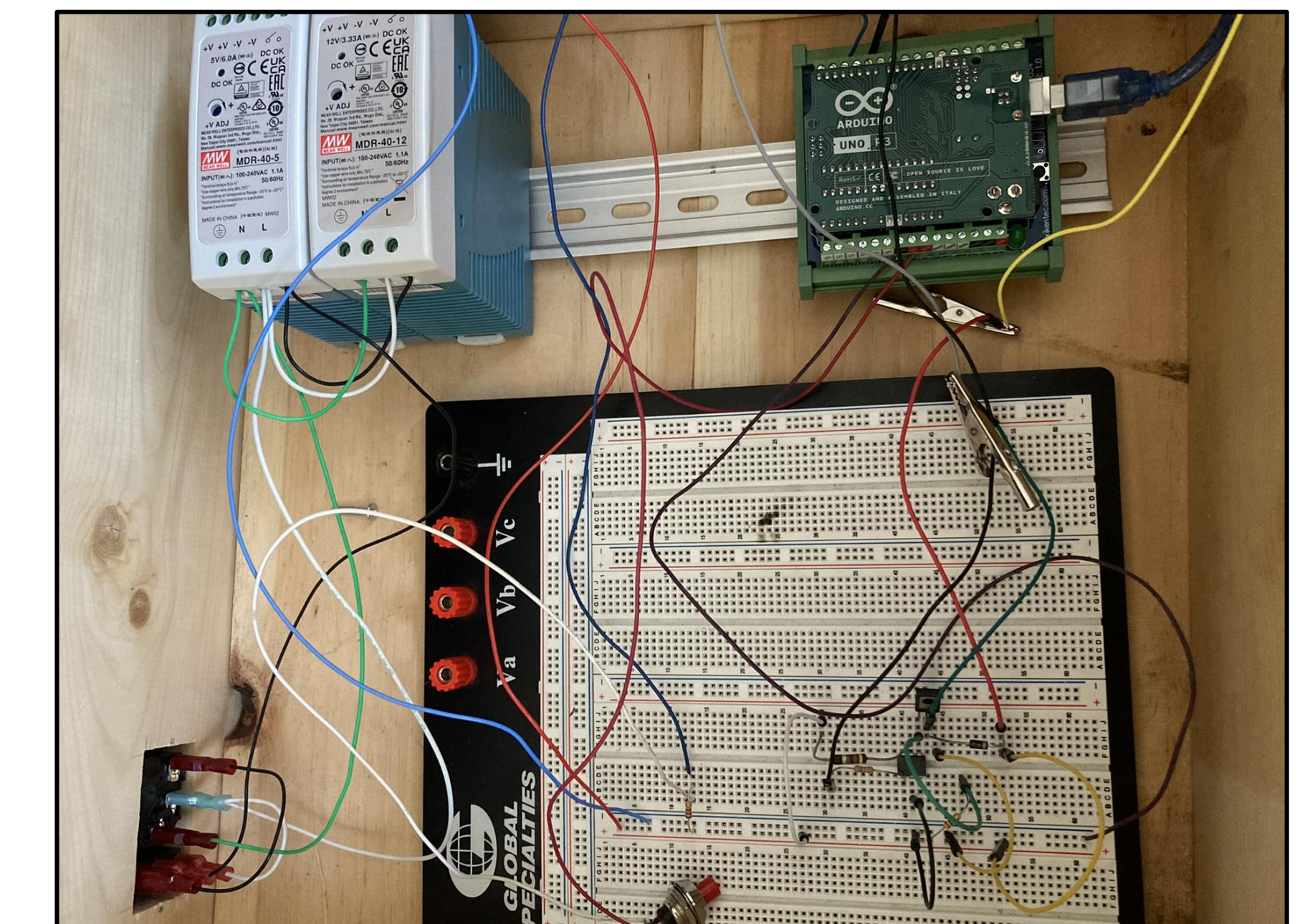


Figure 7: Arduino, printed circuit board, and power supply in the wooden box

Water (Hydraulics)

- Selected 1550-gallon plastic tank to provide 3 psi minimum pressure for the Solenoid valves and the spacing underneath the plumbing and gutter
- Purpose for emergency relief supply during non-winter use to prevent interior freezing damage
- Used NOAA Atlas 14 rainfall data and EPA SWMM (Stormwater Management) to quantify first-flush volume and runoff from the 4000 square feet of roof (see Figure 3).
- Piping sized to 4-inch for inflow and overflow
- Used leaf-eater product for first-flush system

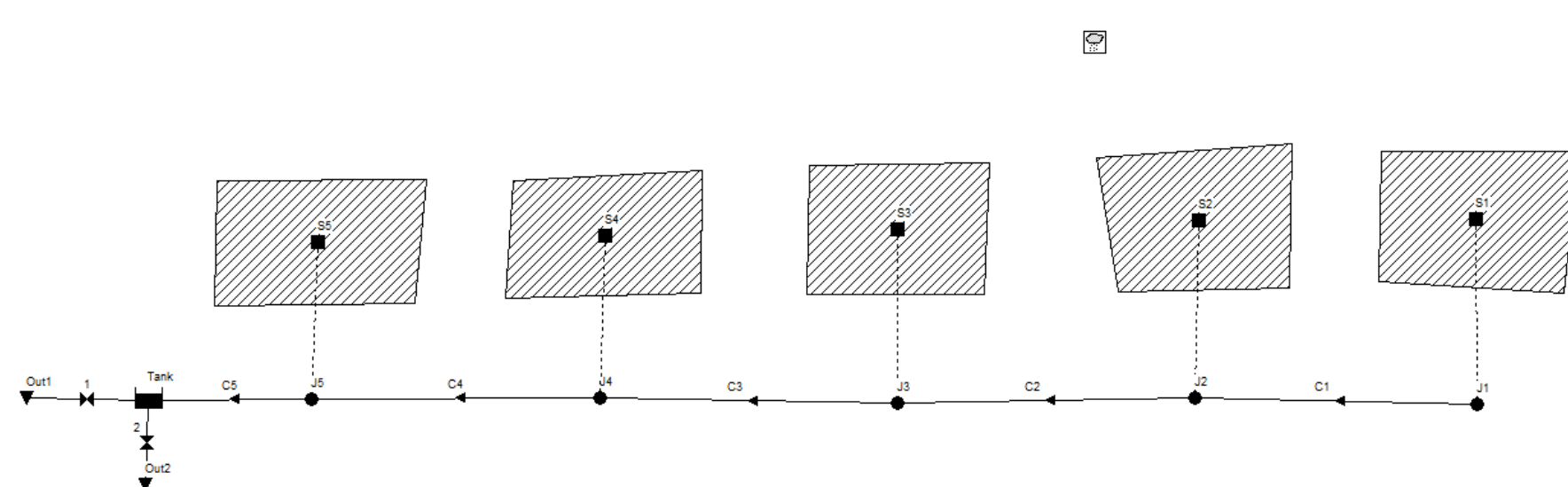


Figure 3: First Flush System with five first-flushes in EPA SWMM Software

Structural

- Used RAM and STAAD.PRO to model tower
- Selected Grade A992 Steel due to strength per unit weight
- Used ASCE 7-10 code book for minimum design loads like wind/snow
- Used AISC Steel Construction Manual, 15th Ed to design beams, columns, and connections
- Supports for pipes every 10 feet using simple beam analysis
- Cable bracing to eliminate buckling (see Figure 4)
- Accounted all loads from maintenance workers to water in tank

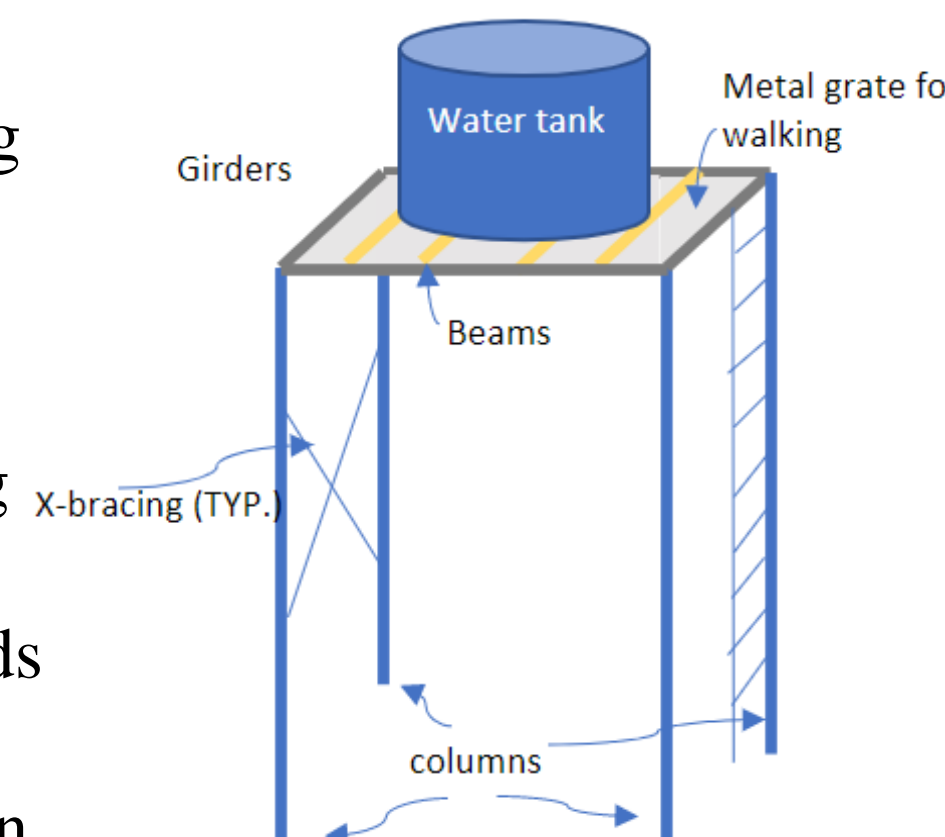


Figure 4: Components of Tower

Electrical

- Used five 12V normally closed Solenoid valves, coded to only open at the right stage of backflushing instead of manually turning them (see Figure 5)
- Used 12V-40W and 5V-40W AC to DC industrial grade din-rail power supplies
- Used Arduino IDE to program microcontroller and a button to trigger the system
- Used printed circuit board with required resistors, diodes, etc

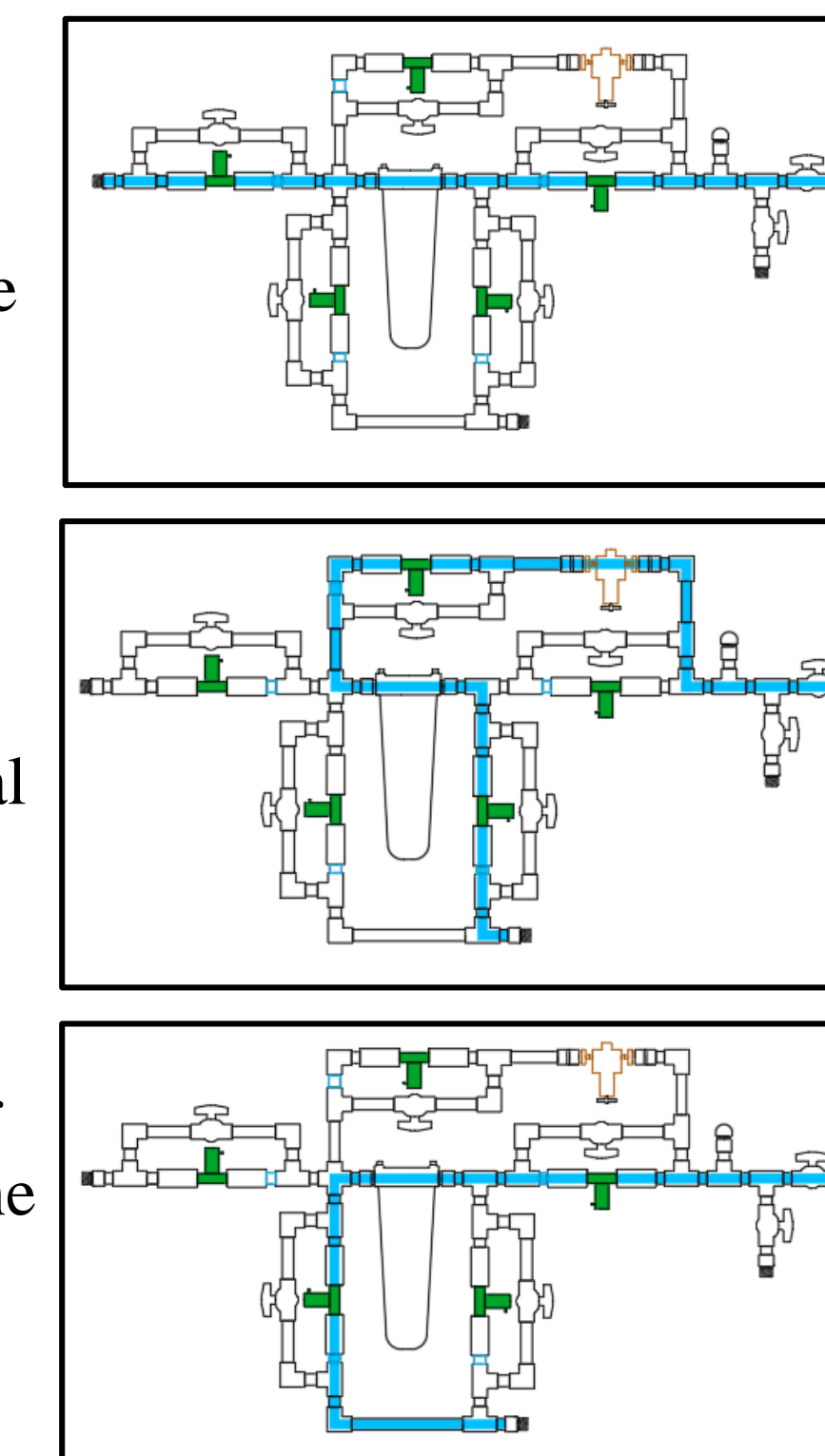


Figure 5: Stages of Backflushing

ACKNOWLEDGEMENTS

Professor DeRooy	(Advisor)
Professor Wildschut	(Hydraulics Assistance)
Professor Brouwer	(Electrical Assistance)
Chuck Holwerda	(Electrical Assistance)
Arnie LeMay	(Water With Blessings Engineer)
Sister Lorraine	(Water With Blessings Director)
Chris Sorenson	(Wood Shop Assistance)
Jeff Gritter	(Consultant Brief P.E.)
Eric DeGroot Fund	