SRP EVAP

ME 476C Spring 2025

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Trey Bushling-CAD Engineer
Jorge Cesin-Financial Manager
Brendan Steele-Test Engineer

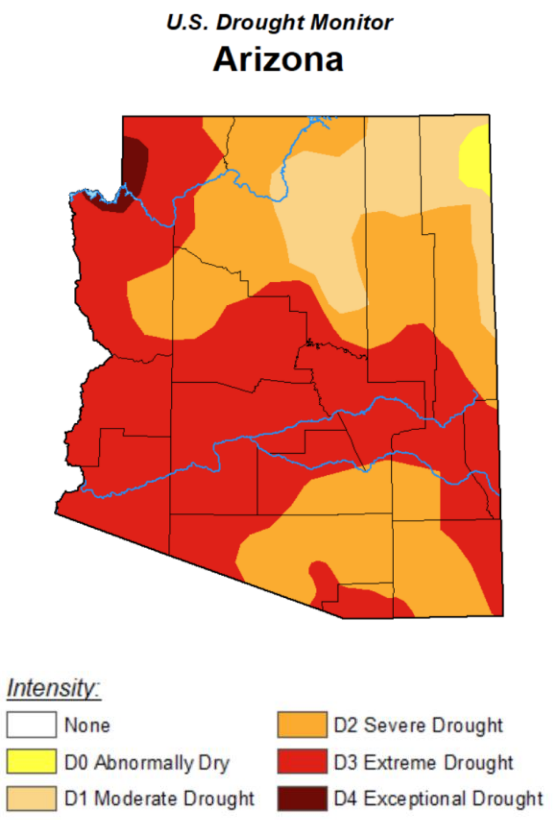
Project Description

- ❑ Objective: Research water evaporation and implement an experimental apparatus to mimic SRP's goal of installing solar panels over canals
- ❑ Sponsored by Dr. Tom Acker, Sr. Principal Engineer, Innovation and Development at Salt River Project.
- ❑ Corporate Goal of SRP: Reduce SRP's carbon emissions by 82% by 2035, net zero by 2050.
- ❑ Interested in renewable energy sources that utilize pre-existing space and provide co-benefits

Picture Credit: Tectonicus

Importance

- Because of extended drought conditions across the state, water conservation is issue of importance for SRP
- Adding solar panels above canals is more expensive than regular ground mounting
- Our study aims to answer the question: Is the co-benefit of water evaporation reduction significant enough for future projects to be worth it?
- Our data will be provided to ASU research team to assist them in their analysis



Credit: Arizona Department of Water Resources [1]

Black Box Model

To differentiate between the types of flows, arrows are categorized as follows: materials are shown with thick black lines, energy is shown with thin black lines, and signals are shown with dashed lines.

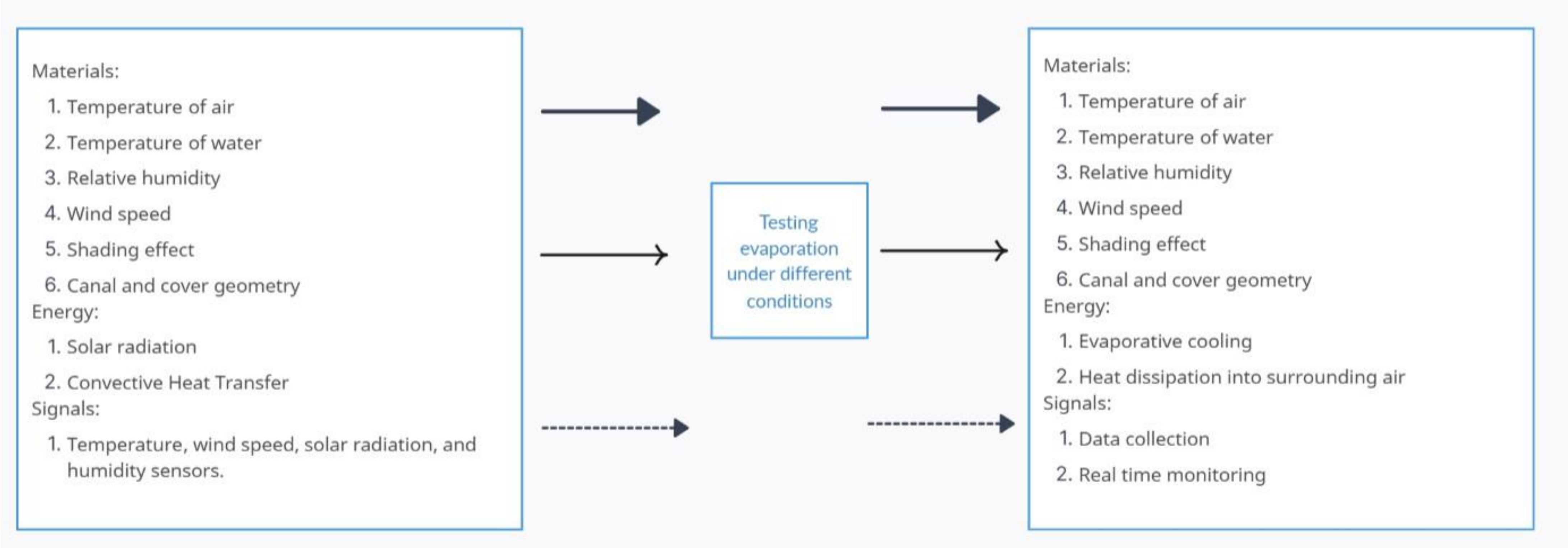
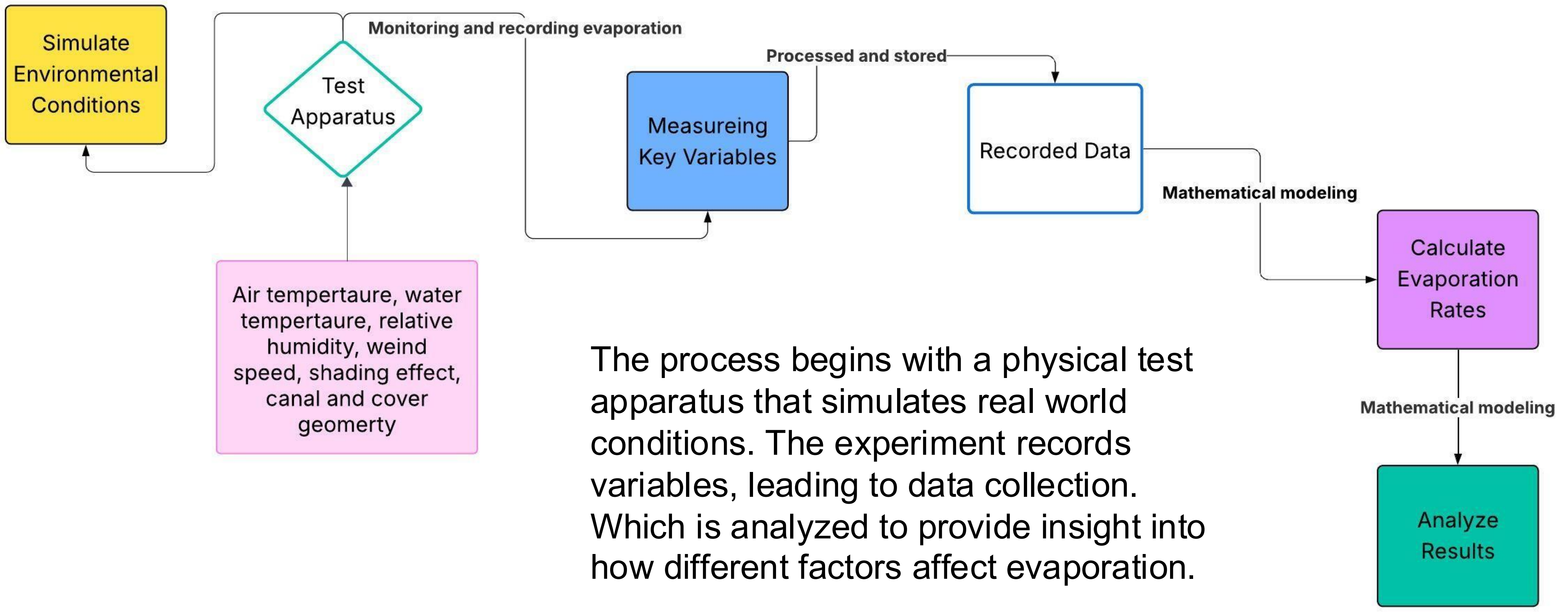


Figure 1: Black Box Model

Samantha Synk, 3/3/2025, SRP EVAP

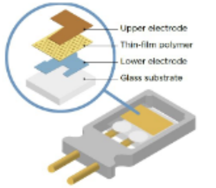
Functional Model



The process begins with a physical test apparatus that simulates real world conditions. The experiment records variables, leading to data collection. Which is analyzed to provide insight into how different factors affect evaporation.

Figure 2: Functional Model

Concept Generation - Morphological Matrix

Concept	Option 1	Option 2	Option 3	Option 4
Humidity	Hydrometer	Hygrometer*	Gravimetric Humidity Sensor	Psychrometer
Scientific methods of recording the humidity within the test apparatus at multiple locations.	Cole-Parmer	 Fine Tools	 Livington Janice JABE	 Fine Art America
Temperature	Thermocouple*	Electric Thermometer	Analog Thermometer	
Methods of recording the temperature at multiple locations such as in the water above the water and the general apparatus.	 RAM-Sensors	 SP-Bell Art	 General Tools	
Wind	Digital Anemometer*	Robinson Anemometer		
Scientific methods of recording the wind speed directly over the surface of the water reservior.	 WinTact	 METEO OMINIUM		

Concept Generation - Design Concepts

Design 1

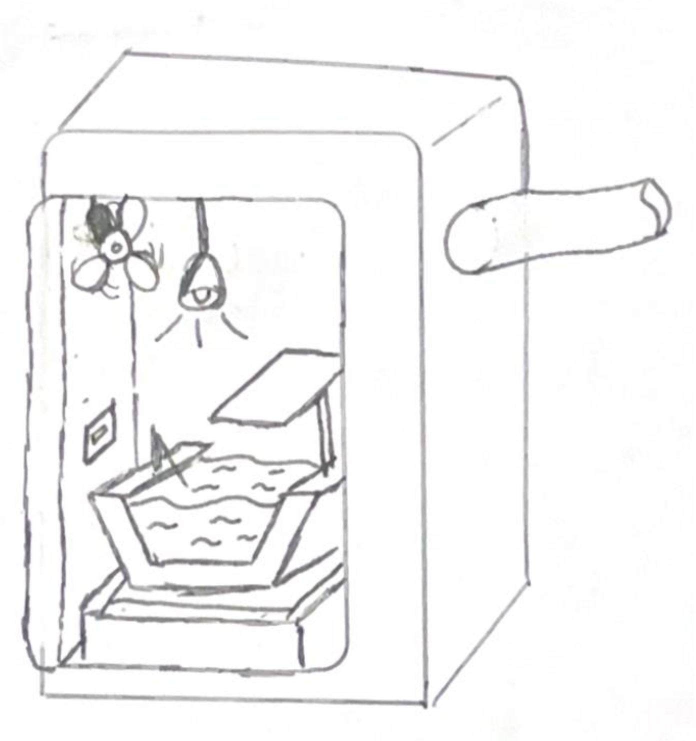


Figure 3: Design 1

Design 2

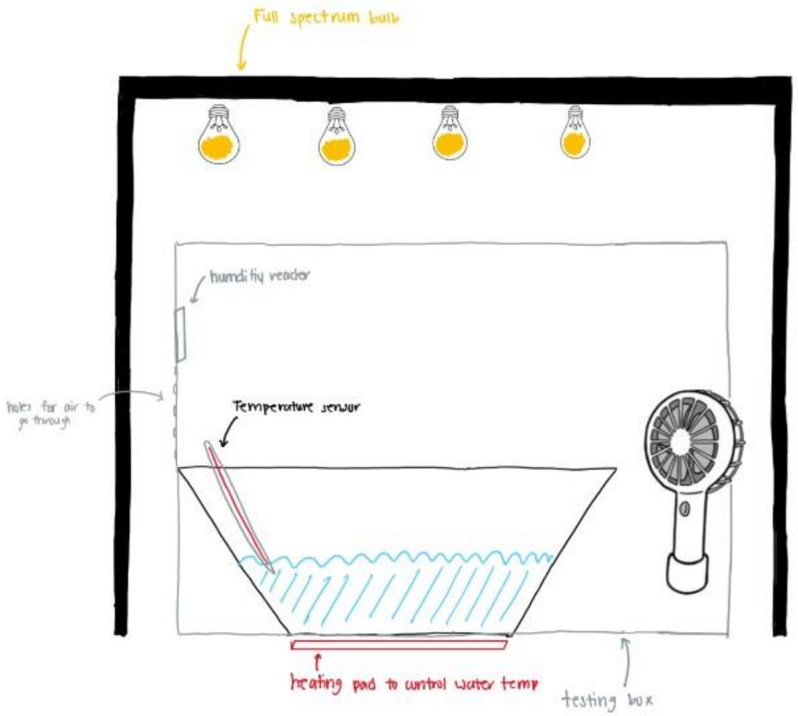


Figure 4 : Design 2

Design 3

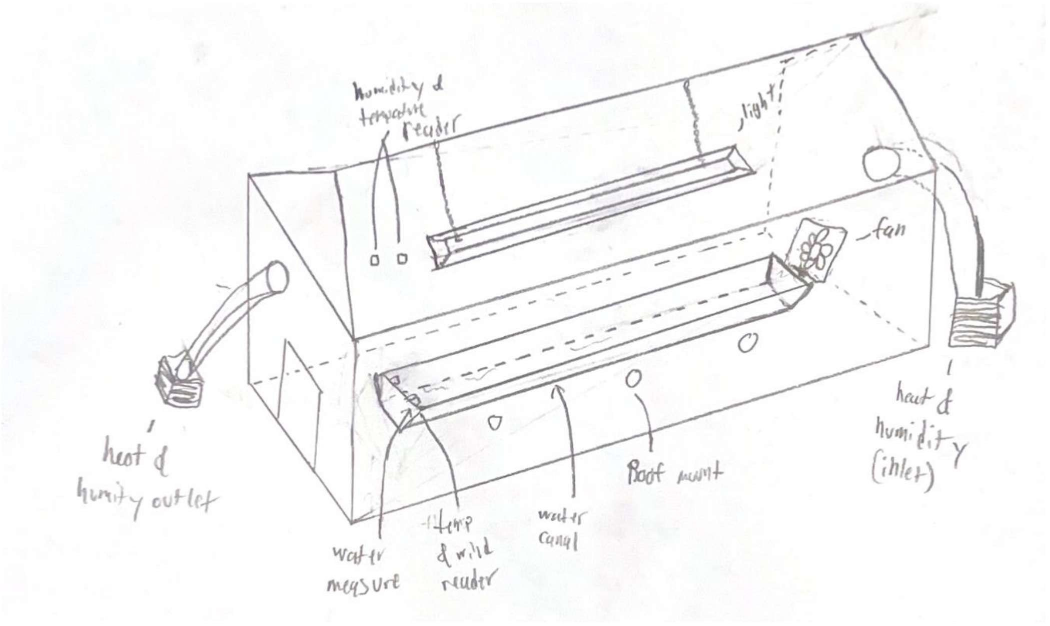
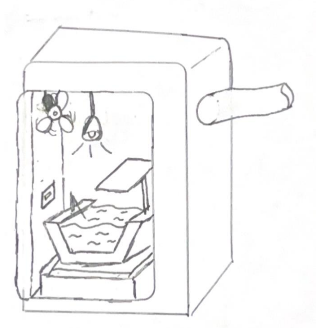


Figure 5: Design 3

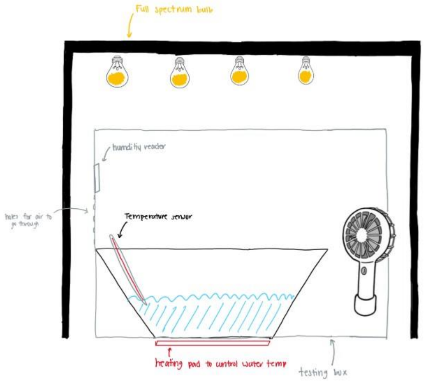
Concept Evaluation - Pugh Chart

PUGH Chart - SRP Evaporation		Concept		
		1	2	3
Criteria	Cost	-	+	-
	Power	+	0	0
	Mobility	+	-	-
	Aparatus Seal	+	-	0
	Size Smaller= better	+	0	-
	Temp Higher=better	+	+	-
	Accesible	-	-	+
	Monitorability	+	-	+
Sum of +		6	2	2
Sum of 0		0	2	2
Sum of -		2	4	4
Total		4	-2	-2

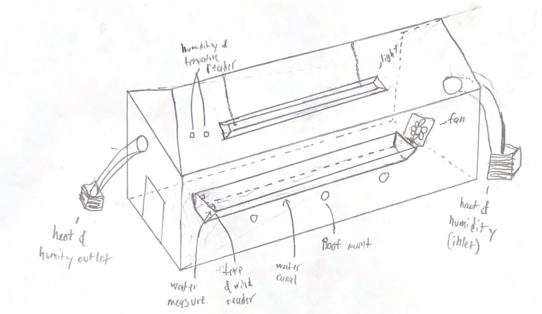
Design 1



Design 2



Design 3



Concept Evaluation – Design Apparatus

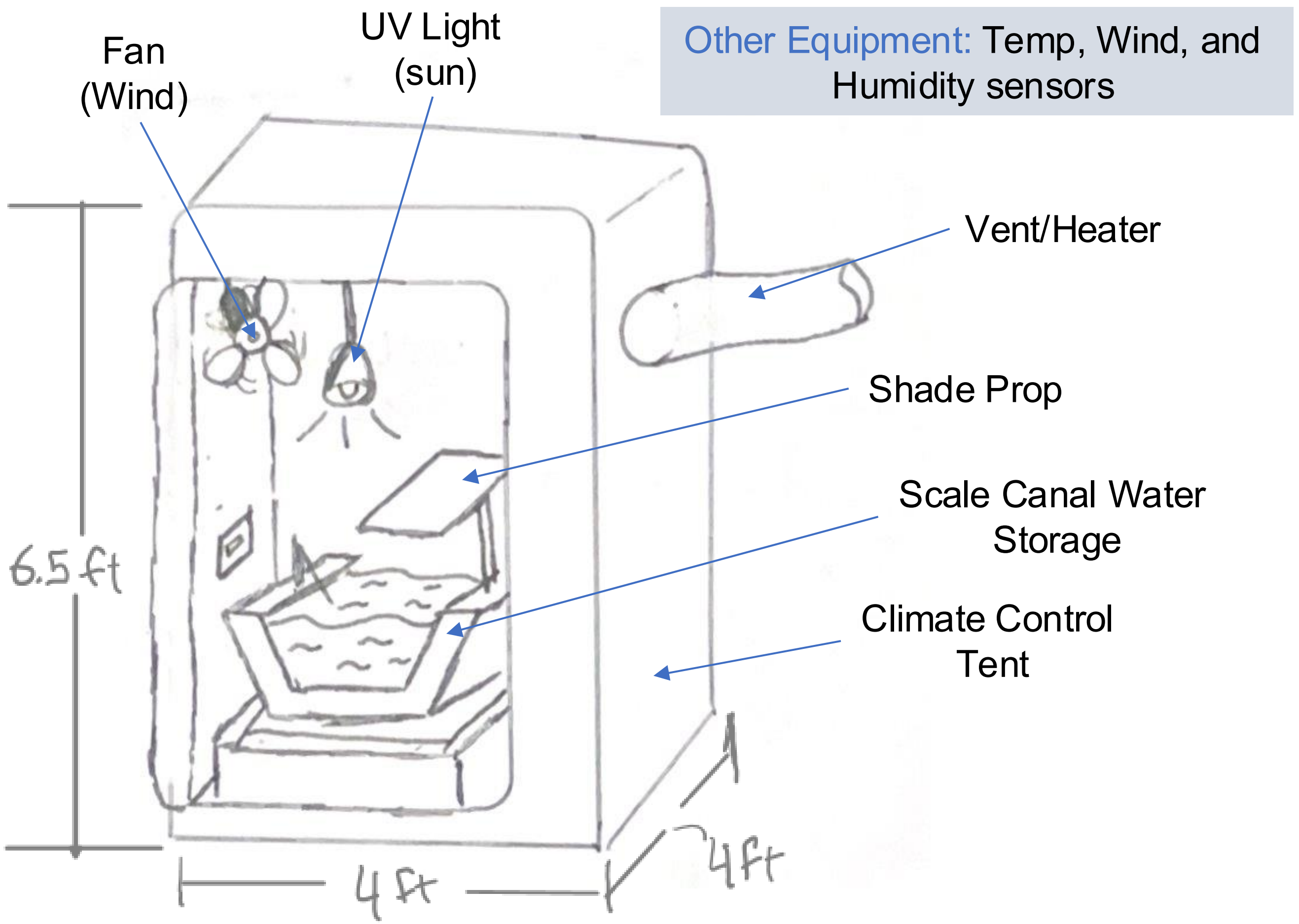


Figure 6: Design 1

Benchmarking:

- ❑ No Benchmarking Apparatus

Pros:

- ❑ Measurement Precision
- ❑ Portable
- ❑ Compactable

Cons:

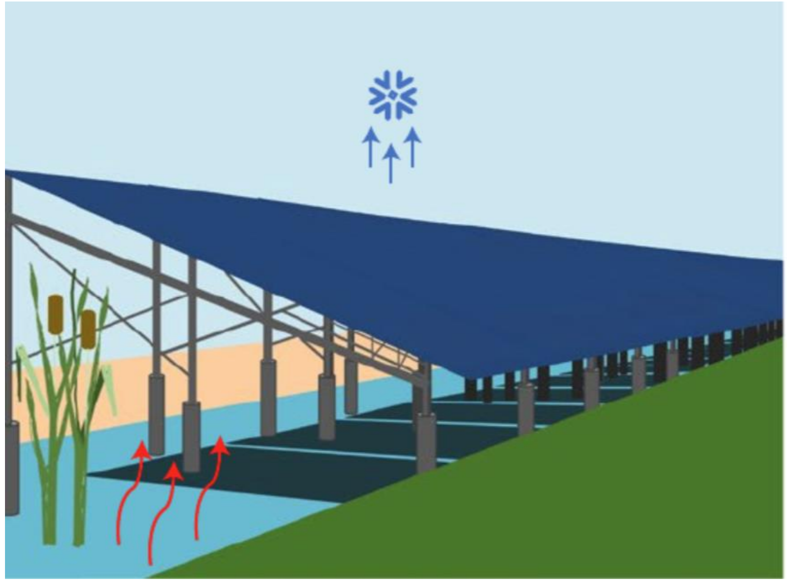
- ❑ High cost
- ❑ Anticipating Malfunctions

General Project Assumptions

These are the base parameters that we will be designing our experiment around:

(In Summer) (U.S. Customary Units)

- ❑ Temperature of Air: 100°F, Temperature of Water(Body): 75°F, Temperature of water(surface):78°F
- ❑ Relative Humidity: 24%
- ❑ Wind Speed: 5.8mph
- ❑ Top Width: 80ft, Bottom Width: 24ft
- ❑ Water Level: 16.5ft, Height of canal: 20ft
- ❑ Height of Roof from Top of canal: 10ft, width: 82ft
- ❑ Still Water, No Clouds
- ❑ No Water Seepage



Picture credit: [4]

Calculations

To ensure that our apparatus has geometric similarity with the canal, a scale of 1' = 40' is applied to dimensions of the canal. We plan to make our water container 2' x 2'.

Dimensions of the canal:

$$w_{top} = 80\ ft$$

$$w_{bottom} = 24\ ft$$

$$w_{@\ water} = 70.2\ ft$$

$$l_{wall} = 34.4\ ft$$

$$h_{canal} = 20\ ft$$

$$h_{water} = 16.5\ ft$$

Dimensions of our apparatus:

$$w_{top} = 24\ in$$

$$w_{@\ water} = 21.1\ in$$

$$l_{wall} = 10.3\ in$$

$$\frac{80ft}{24ft} = \frac{2ft}{w_{bottom}} \Rightarrow w_{bottom} = 7.2\ in$$

$$\frac{80ft}{20ft} = \frac{2ft}{h_{canal}} \Rightarrow h_{canal} = 6\ in$$

$$\frac{80ft}{16.5ft} = \frac{2ft}{h_{water}} \Rightarrow h_{water} = 4.95\ in$$

Heights of the covers over the water surface will be:

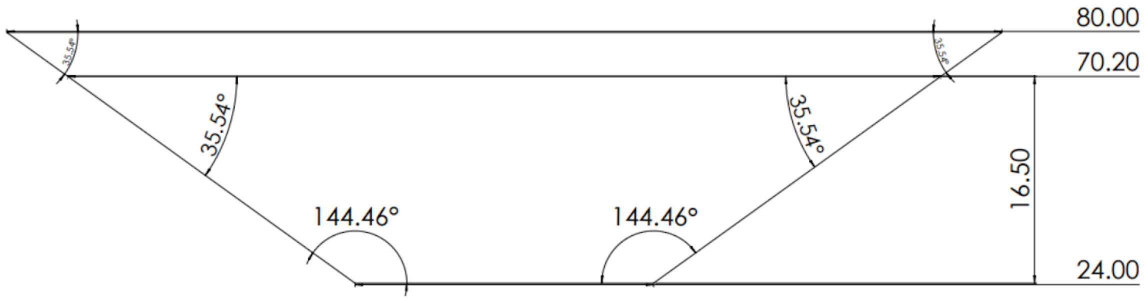
$$\frac{80ft}{3ft} = \frac{2ft}{h_{cover}} \Rightarrow h_{cover} = 0.9in$$

$$\frac{80ft}{10ft} = \frac{2ft}{h_{cover}} \Rightarrow h_{cover} = 3in$$

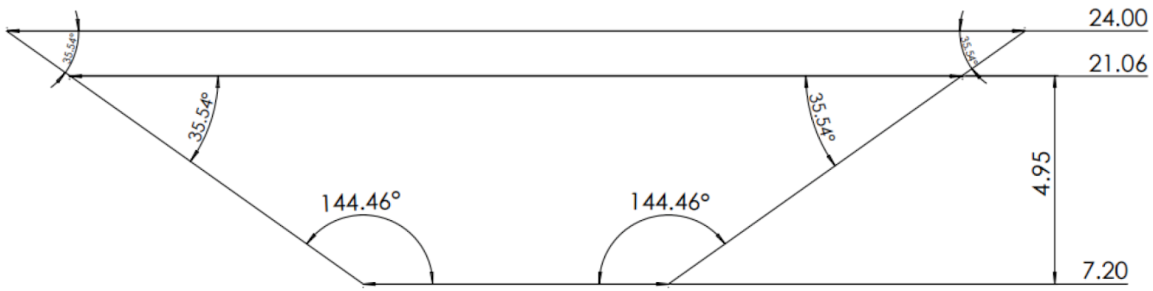
$$\frac{80ft}{15ft} = \frac{2ft}{h_{cover}} \Rightarrow h_{cover} = 4.5in$$

Calculations

Drawings made in SolidWorks to test the geometric similarity from calculations. Geometric similarity will ensure that the data collected from our apparatus can be directly applied to life size situations.



Drawing 1: dimensions of canal in feet



Drawing 2: dimensions of canal model in inches

CAD Model

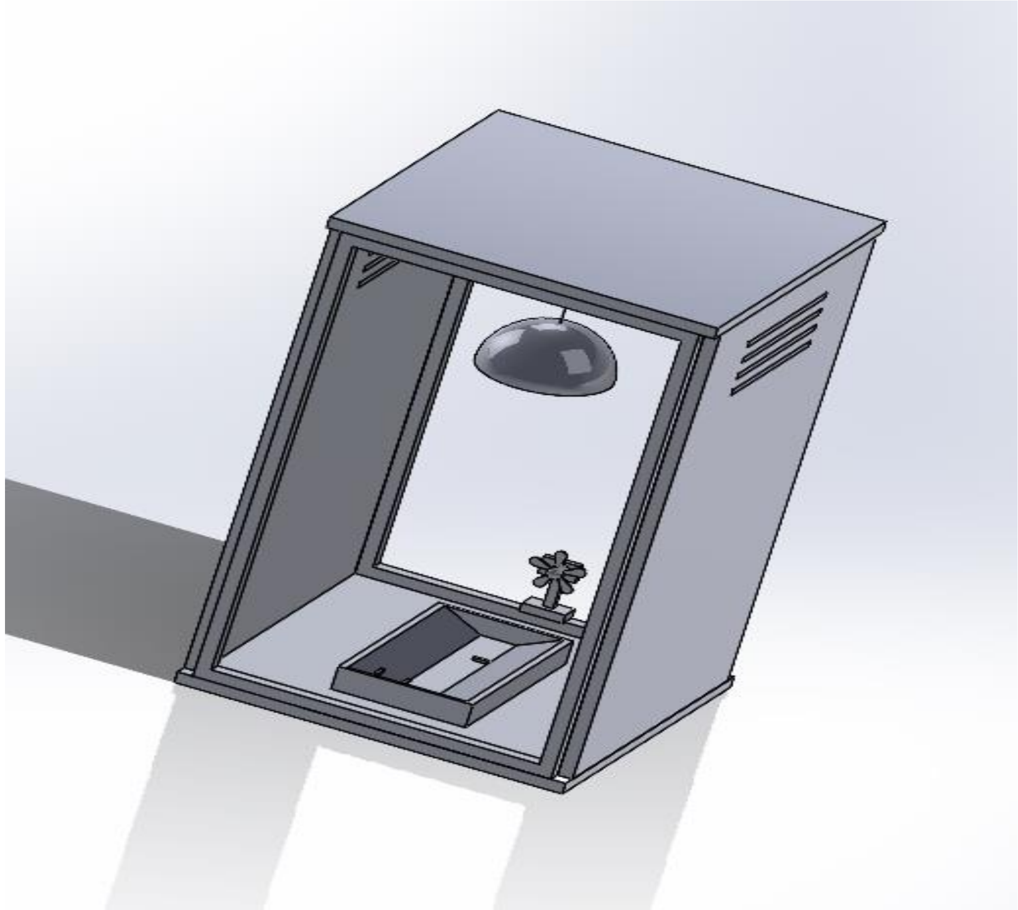


Figure 7: CAD Model

- Sealed
- Measuring Devices
- Sun (UV light system)
- Wind (Fan)
- Canal
- Ventilation
- 4x4ft area top and bottom
- 4x6.5ft area on walls
- Canal width top 2ft, bottom width .6ft, length 2ft

Bill of Materials

Bill of Materials:

For the teams bill of materials, a list of materials needed to test for the main experiment has been listed out with the estimated price.

Due to the clients request of not creating a prototype and giving the team a goal of only testing for evaporation, all materials purchased will be for experimental purposes.

Bill of Materials			
Component	Unit Quantity	Description	Unit Cost
Climate Tent	1	Tent in order to control variables like humidity and evaporation	\$200 - \$700
Full Spectrum Bulb	6	Full Spectrum Bulb to simulate evaporation from the sun	\$10 - \$40
Humididty Reader	3	Humididty reader to accuratly read the humidity in the green house. This will be used to create a constant humidity before each test.	\$5 - \$80
Temperature Sensor	6	Temperature Sensor to read temperature at the top of the tent and right above the water.	\$20 - \$150
Water Tank	2	Water tank to hold water. 2 units just incase the primary one breaks.	\$10 - \$100
Heater	1	Heater to properly set the temperature inside the tent.	\$50 - \$100
Fan	2	Fan to simulate wind.	\$20 - \$200
Wind Sensor	2	Wind Sensor to test for wind variables.	\$25 - \$300

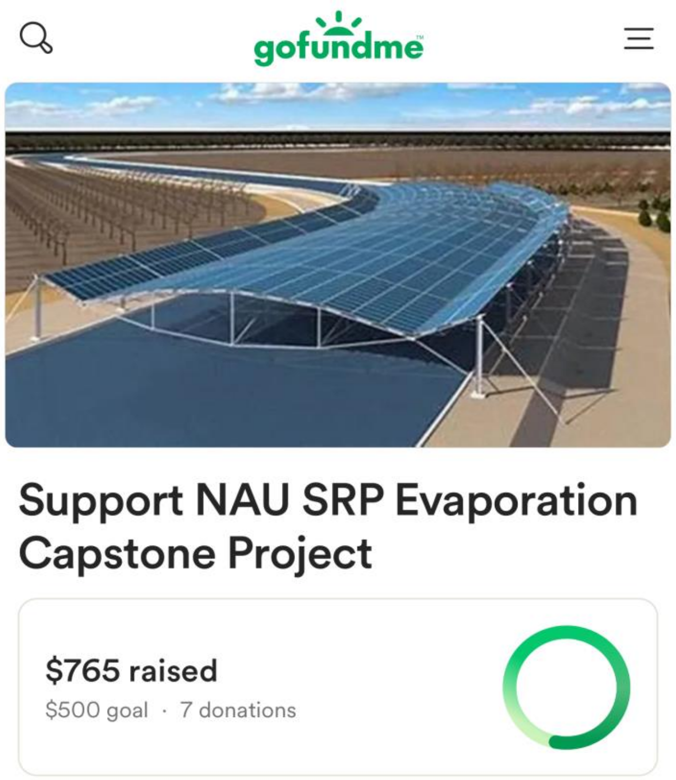
Project Budget

Overall Budget:

Our overall budget is $5,000, with the majority of the budget going to testing and experimentation. A portion of the budget will go towards traveling to the ASU campus to see the prototype

Item	Category	Description	Total
SRP Comp. Funding	Funds	$5,000 to use on evaporation research	$5,000
Fundrasing	Funds	A minimum of 10% of the total fund needs to be fundraised by the group	$765
		Estimated Total:	$5,765

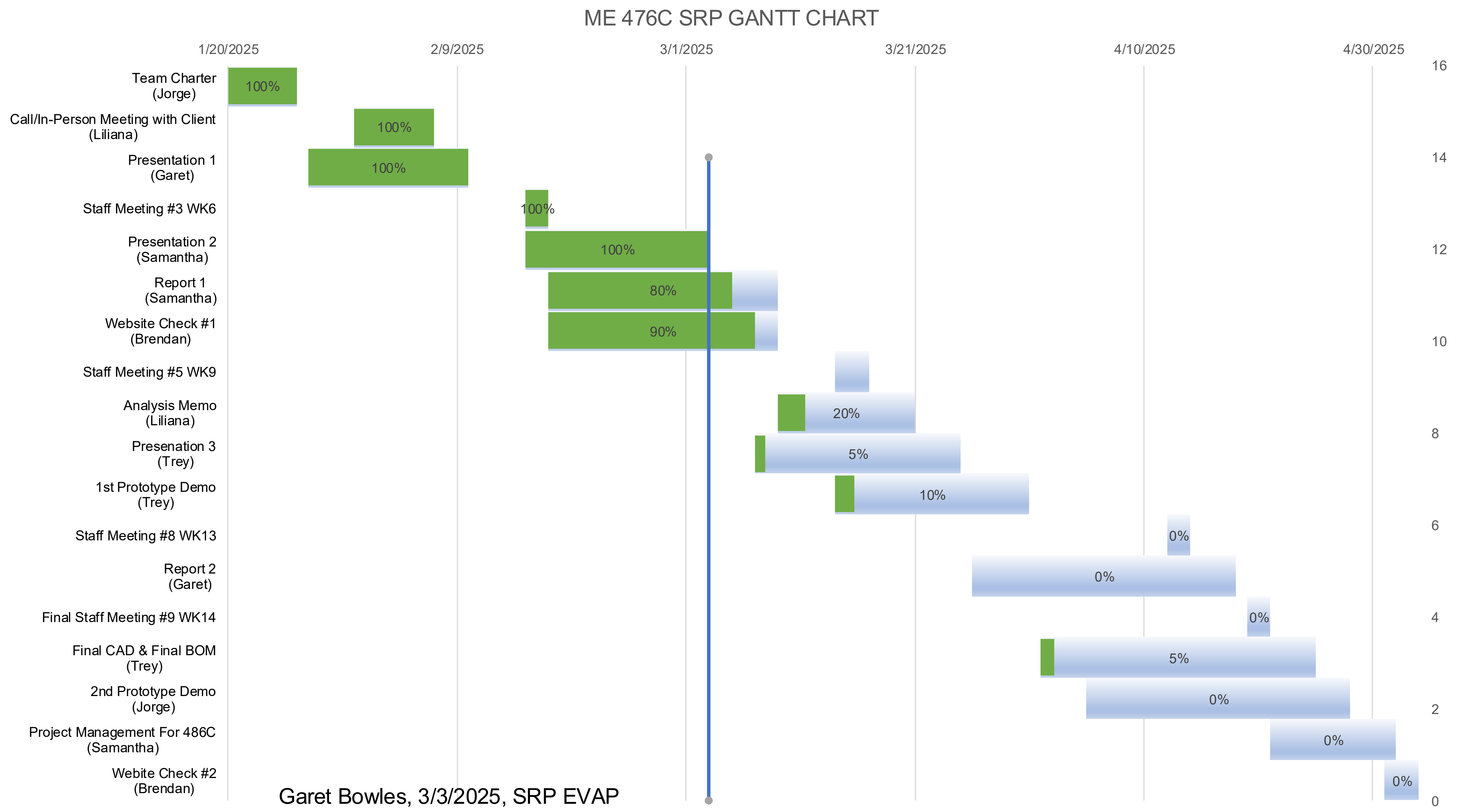
Trip to ASU Campus in Tempe	
Gas	~$60 (Round Trip)
Hotel	N/A / Undecided
Food	~ $150 ($25 Each)
	Total: ~$210



Fundraising:

As a team, we set up a go fund me that has so far raised $765, with a goal of $500.

Item	Category	Description	Unit Cost	Quantity	Costs
Climate Tent	Tests/Experiments	Tent in order to control variables like humidity and evaporation	$200 - $700	1	$200 - $700
UV Lamp	Tests/Experiments	UV lamp to simulate evaporation from the sun	$10 - $40	6	$60 - $240
Humidity Reader	Tests/Experiments	Humididty reader to accuratly read the humidity in the green house. This will be used to create a constant humidity before each test.	$5 - $80	3	$15 - $240
Temperature Sensor	Tests/Experiments	Temperature Sensor to read temperature at the top of the tent and right above the water.	$20 - $150	6	$120 - $900
Water Tank	Tests/Experiments	Water tank to hold water. 2 units just incase the primary one breaks.	$10 - $100	2	$20 - $200
Heater	Tests/Experiments	Heater to properly set the temperature inside the tent.	$50 - $100	1	$50 - $100
Fan	Tests/Experiments	Fan to simulate wind	$20 - $200	2	$40 - $400
Wind Sensor	Tests/Experiments	Wind Sensor to test for wind variables.	$25 - $300	2	$50 - $600
				~Total Cost:	$555 - $3,380

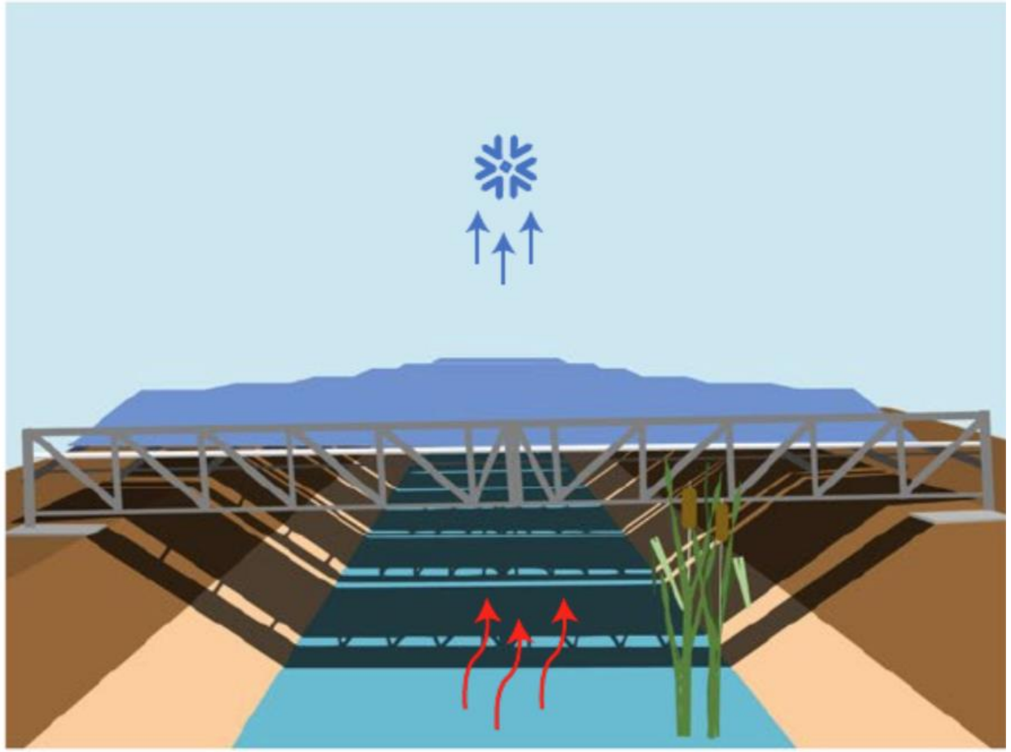


ME 476C SRP GANTT CHART
1/20/2025
2/9/2025
3/1/2025
3/21/2025
4/10/2025
4/30/2025
Team Charter (Jorge)
100%
Call/In-Person Meeting with Client (Liliana)
100%
Presentation 1 (Garet)
100%
Staff Meeting #3 WK6
100%
Presentation 2 (Samantha)
100%
Report 1 (Samantha)
80%
Website Check #1 (Brendan)
90%
Staff Meeting #5 WK9
Analysis Memo (Liliana)
20%
Presenation 3 (Trey)
5%
1st Prototype Demo (Trey)
10%
Staff Meeting #8 WK13
0%
Report 2 (Garet)
0%
Final Staff Meeting #9 WK14
0%
Final CAD & Final BOM (Trey)
5%
2nd Prototype Demo (Jorge)
0%
Project Management For 486C (Samantha)
0%
Webite Check #2 (Brendan)
0%
16
14
12
10
8
6
4
2
0
Garet Bowles, 3/3/2025, SRP EVAP

Conclusion

Future Work

- Heat and Mass Transfer analysis
- Non-dimensionless equations
- Decided final design
- Mathematical models to show how combined factors effect evaporation
- High-quality labeled drawing in Solidworks
- Have physical hand out of parts



Picture credit: [4]

Thank You!

Refrences

[1] "Drought Status | Arizona Department of Water Resources," *Azwater.gov*, 2024. https://www.azwater.gov/drought/drought-status

[2] "Fundamentals of heat and mass transfer, 8th edition," Wiley.com, https://www.wiley.com/en-us/Fundamentals+of+Heat+and+Mass+Transfer,+8th+Edition-p-9781119353881 (accessed Feb. 8, 2025).

[3] Fundamentals of Engineering Thermodynamics: Moran, Michael J., Shapiro, Howard N., Boettner, Daisie D., Bailey, Margaret B.: 9781118412930: Amazon.com: Books, https://www.amazon.com/Fundamentals-Engineering-Thermodynamics-Michael-Moran/dp/1118412931 (accessed Feb. 9, 2025).

[4] B. McKuin *et al.*, "Energy and water co-benefits from covering canals with solar panels," *Nature Sustainability*, Mar. 2021, doi: https://doi.org/10.1038/s41893-021-00693-8.

[5] W. Wang et al., "Estimating evaporation from irrigation canals in the midstream areas of the Heihe River basin by a double-deck surface air layer (DSAL) model," MDPI, https://www.mdpi.com/2073-4441/11/9/1788#B18-water-11-01788 (accessed Mar. 2, 2025).