An Investigation Into Water Purification And Research Into A Viable Design Solution

IB Candidate Code: kfm664

IB Design Technology

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Problem Statement (200 Words):

Research indicates that poor sanitation and the lack of access to clean water within underdeveloped areas of the world require water purification solutions. In accordance with data collected through UNICEF, I confirmed that over 367 million people rely upon unimproved water sources while another 122 million still obtain water via natural sources.[1] These problems revolving around the lack of accessible clean water can often be linked to the spread of diseases, such as diarrhea, dysentery, and polio, and, subsequently, higher mortality rates.[2] This design opportunity, is to create a product that purifies the unsuitable water of developing communities and utilizes practical design in a way that requires little maintenance.

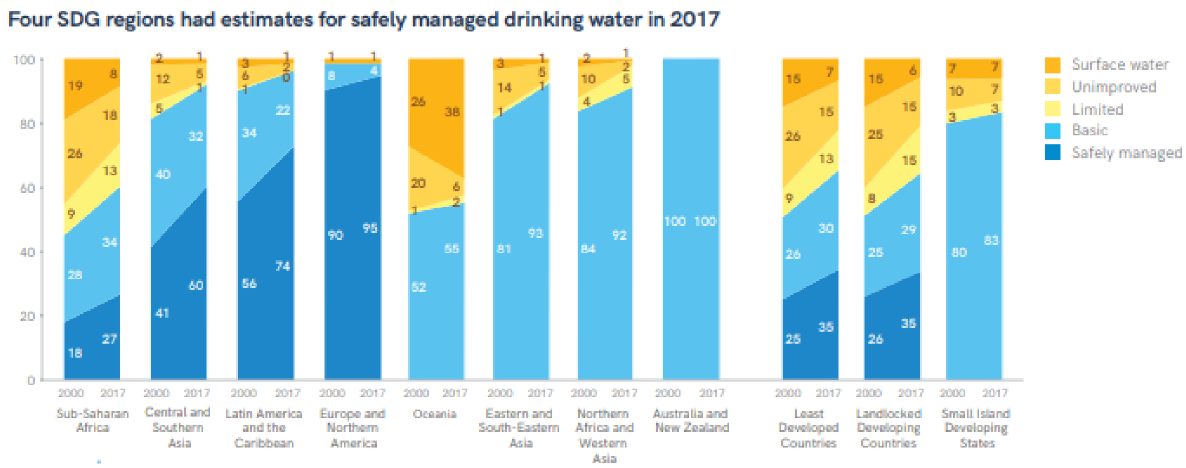


Figure-1: Drinking water coverage(2000-2017)[3]

In studying this global issue, I conducted user research by reaching out to Jayson Bryson from “The Water Project” to discuss the extent of the clean water crisis on a global scale. In our discussion, I was told that “purification solutions are needed in areas of Kenya, Uganda, and other regions of Sub-Saharan Africa” (Figure 1). Furthermore, we discussed that this lack of functional purification solutions resulted from the inability to provide purification maintenance to specific regions of these communities and the lack of electric infrastructure.

Design Brief (150 Words):

Through the development of this product, key accessibility factors must be taken into account in order to achieve its target societal impact and ensure the trust of its beneficiaries. The conceptual goal of this product, at its core, is to provide clean (WQS Satisfactory) water, at a sustainable/supportable rate, to underdeveloped communities on a global scale.

With this focus in mind, this product must:

[1] The Water Project. (2016). Facts and Statistics about Water and Its Effects. The Water Project. https://thewaterproject.org/water-scarcity/water_stats
[2] World Health Organization. (2022, March 21). Drinking water. Who.int; World Health Organization: WHO. https://www.who.int/news-room/fact-sheets/detail/drinking-water
[3] Ritter, K. (2019, June 28). 2.2 billion people still don’t have access to clean drinking water. World Economic Forum. https://www.weforum.org/agenda/2019/06/hotspots-h2o-new-un-report-details-global-progress-and-problems-with-access-to-safe-water-and-sanitation

- Be accessible in its collection and dispensation of water
- Be composed of sustainable yet durable materials to endure the environmental strain
- Retain usage/production efficiency across many target environments without the need for maintenance
- Present afforded functionality without language barriers
- Consider user safety in size constraints; Stable design unlike other experimental (not lasting) products[4]
- Consider the mobility and the ease of product distribution, especially in worldly regions with lacking infrastructure
- Maintain a consistent profile amongst other daily applications
- Provide reliably clean drinking water

Design Specifications (800 Words):

Specification:	The prototype should…	Rationale:
Target Market	Be designed for use outside of the home and in robust environments	A significant amount of families across the world struggle to develop a sustainable source of clean water through only the utilization of their natural environment. These families are (on average) larger than families in wealthier nations and require that the product serve 4+ (the mean family) human beings. With a focus on families, this product also must consider usage around small children and, in turn, must avoid sharp edges/features that may prove harmful in the field.
	Be designed for use by all age groups and take into safety considerations required of use around small children (age 3-8)	
	Be designed to provide for the drinking water requirements families of 4	
Target Audience	Be designed for affording use by the majority of the world's population, especially focusing on underdeveloped, perhaps uneducated, communities	This product must be designed for primary non-profit and humanitarian movements that wish to deploy such clean water resources to worldly consumers. In this sense, this product must utilize little language barrier within instruction so as to not make specific users obsolete. In addition, this product must be made to ship and sustain its structure during longer exhibitions/journeys to underdeveloped

[4] Creative, K., Killum and Wynn, & Wellbots. (n.d.). GoSun Flow Solar Water Purifier + Pump. Wellbots. Retrieved October 3, 2022, from https://www.wellbots.com/products/gosun-flow-solar-water-purifier-pump?variant=40382880579632&dfw_tracker=14110-40382880579632&gclid=Cj0KCQjwkOqZBhDNARIsAACsbfKvSwGr36-r1Wu1tbPeebXi698GZo5YQ0DyETs6Qrec74536MUCmlIaAsl6EALw_wcB

	Be designed for transportation and mobility to best assist first-hand efforts and philanthropic exhibitions	consumer bases.
	Provide functionality without language barriers; provide obvious visual indicators for function	
User Requirements	Provide WQS satisfactory drinking water at a sustainable and substantial rate (1 gallon per day per person up to 4).	From conducted research, the average human requires 1 gallon of drinking water per day and, especially in underdeveloped communities, many traditional resources, such as electricity and maintenance, are unavailable to the average consumer.[5]
	Be mobile in its transportation as well as stable when stationary	
	Utilize common dispense methods for water expulsion and collection.	
	Be consistent in function and provide longevity without the need for maintenance.	
Market Requirements & Competition	Be inclusive in functionality to incorporate all users	This product must consider a wide variety of consumers within our market as many will use this product for omnipresent purposes that require consistent usage/attention. In order to achieve such abundance, this product must function with exceptional efficiency and provide an outer aesthetic that is appealing/iconic to the market of interest.
	Provide competitive aesthetic and functional efficiency.	
Functional Requirements	Provide WQS satisfactory drinking water at a sustainable and substantial rate (1 gallon per day per person up to 4).	The exported clean water from the product must meet the standards of the WQS to avoid liability concerns regarding the health of individual customers. In addition, the product must be ready to store a total of 16 gallons of water to best provide for the necessities of its target market.
	Provide ample dirty (or input) water storage (up to 8 gallons each of dirty and	

[5] Philadelphia Water Department. (n.d.). Water.phila.gov. Retrieved October 3, 2022, from https://water.phila.gov/pool/files/home-water-use-ig5.pdf

<table>
<tr><td></td><td>cleansed-output water)</td><td></td></tr>
<tr><td rowspan="2">Aesthetic Requirements</td><td>Be designed to blend into the natural environment: use green, brown, and black palettes.</td><td rowspan="2">By utilizing a more natural palette, the product becomes less of a distraction and, instead, better incorporate itself as an omnipresent feature within the lives of its target users.</td></tr>
<tr><td>Maintain a consistent profile amongst other daily applications</td></tr>
<tr><td rowspan="3">Material Requirements</td><td>Be lightweight for after-purchase transportation.</td><td rowspan="3">By making the product lightweight for in-home transportation, it grants users greater freedom to customize the product and associate it with better conditions for purification. In addition, by using PLA material that repels water and environmental damage for a considerable time period of the product's life, the product earns the omnipresence, in the scope of providing clean water, for which it requires.</td></tr>
<tr><td>Be environmentally sustainable/durable and safe for daily human interaction</td></tr>
<tr><td>Be able to endure internal water strain without need for material replacement or repair</td></tr>
<tr><td rowspan="2">Size Constraints</td><td>Be mobile in its user carry capacity (20lbs - 40lbs</td><td rowspan="2">It is specifically aimed towards usage by adults of all ages and, therefore, must retain weight/size constraints that match the strength of the 5th-95th percentile. These weight and size limitations allow this percentile to carry and move the product to their liking.</td></tr>
<tr><td>Must consider the height of an adult human for water dispensation (average 5’5)</td></tr>
<tr><td rowspan="2">Cost Constraints</td><td>Cost less than $150, given modern manufacturing, to produce and should sell for under $250.</td><td rowspan="2">The market analysis highlights the range of product costs based on the material requirements:

3D printed material (PLA) (outer layering): $40-$55+

Lens (Upper bound): $40+

Hind legs (PLA): $30+

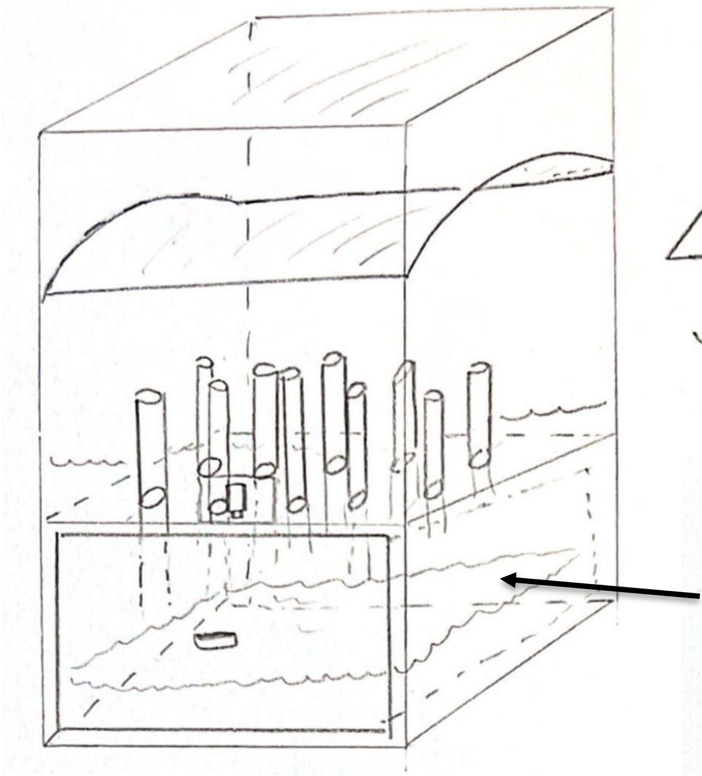
Hinges, Screws, Adhesive Material, etc.: $35+</td></tr>
<tr><td>Cost less than $200 to produce a sustainable, as well as functional, prototype</td></tr>
<tr><td>Manufacturing Requirements</td><td>Be designed for mass manufacturing and incorporate standardized techniques/equipment/parts to increase the ease of production</td><td>By incorporating common manufacturing processes, the product becomes easier to mass-produce and distribute into the marketplace/field.</td></tr>
</table>

Specification Key:			
TM TA UR MRC FR	Target Market Target Audience User Requirements Market Requirements & Competition Functional Requirements	AR MR SC CC M	Aesthetic Requirements Material Requirements Size Constraints Cost Constraints Manufacturing Requirements

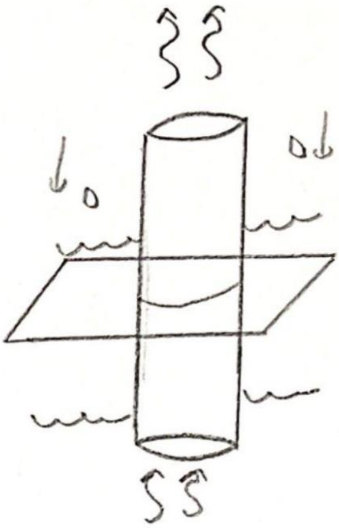
STAGE 1: Sketching & Designing

Design #1: "The Skyscraper"

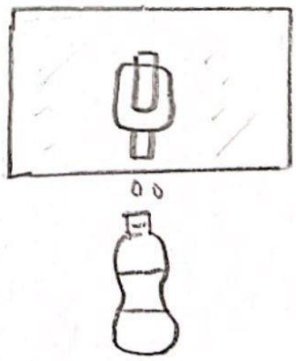
Isometric View



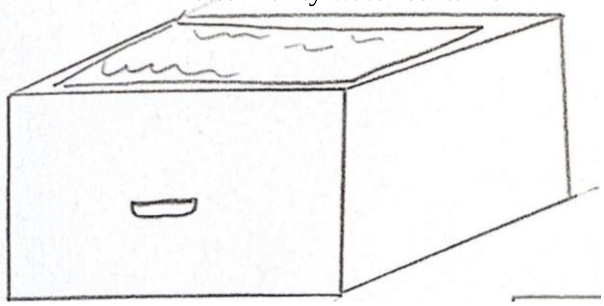
Clean water evaporating and falling back down around tube



Water dispenser



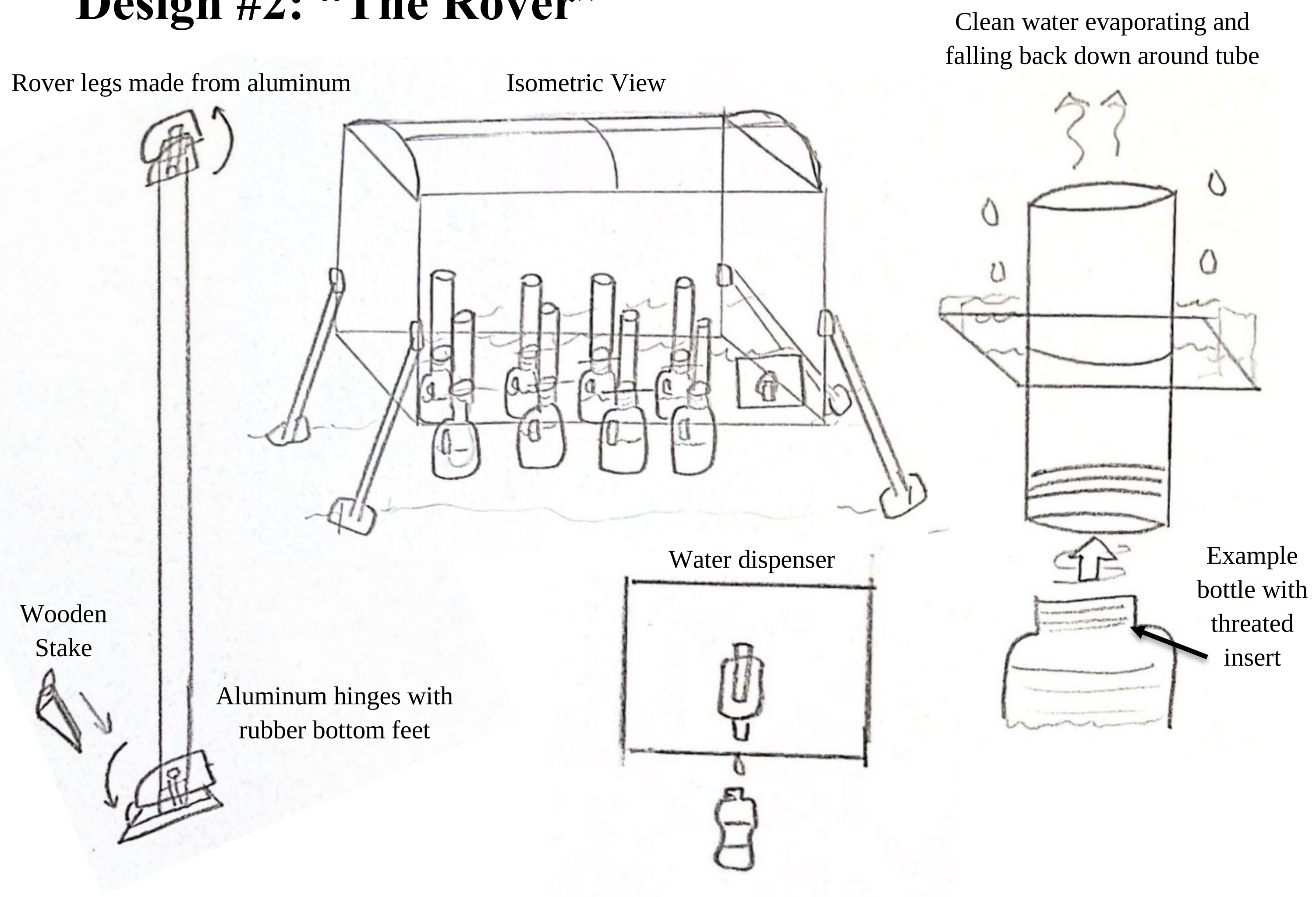
Bottom dirty water container



Pros:		Cons:	
MRC	Compact (relatively small surface area), all-in-one system for the house (easy to access clean water)	SC	Immobile (>40lbs) and large heavy dirty water compartment (away from the source)
MR	Closed system; resistive to environmental elements	TA	Long internal tubes make it fragile to transport (would need to have detachable components to add protective foam for transport)
CC	Composed of biodegradable PLA material (lasting - inexpensive)	UR	Distills less than 1 gallon/day (the requirements for a single person). Needs a greater surface area.
FR	Meets WQS drinking water standards	UR	Difficult to clean/maintain without outside help
FR	Storage of 2-3 gallons each for dirty and distilled water.		

STAGE 1: Sketching & Designing

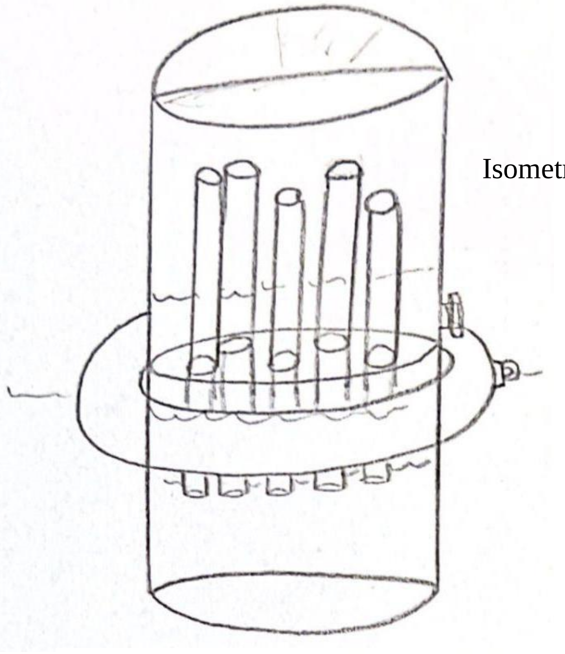
Design #2: "The Rover"



Pros:		Cons:	
MRC	Compact (relatively small surface area), all-in-one system for the house (easy to access clean water)	M	Impossible to make bottle nozzles to adjust for every type of removable container (if the product includes custom bottles, they would need greater plans for replacement/maintenance)
SC	Mobile (~20lbs) and smaller lightweight dirty water component (away from the source)	TA	Long internal tubes make it fragile to transport (would need to have detachable components to add protective foam for transport)
CC	Composed of biodegradable PLA material (lasting - inexpensive)	UR	Distills less than 1 gallon/day (the requirements for a single person); Difficult to clean/maintain without outside help
FR	Meets WQS drinking water standards	UR	Long detachable legs have aluminum joints that weaken over time; Need maintenance/tightening across time
FR	Storage distributed amongst smaller removable bottles	MR	Open system; susceptible to environmental damage due to open ports on the bottom.

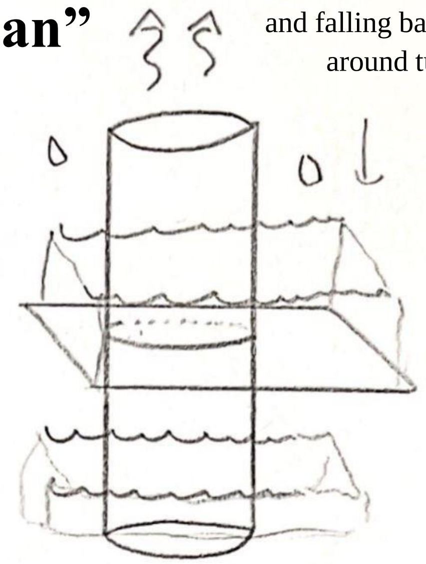
STAGE 1: Sketching & Designing

Design #3: "The Floating Trash Can"

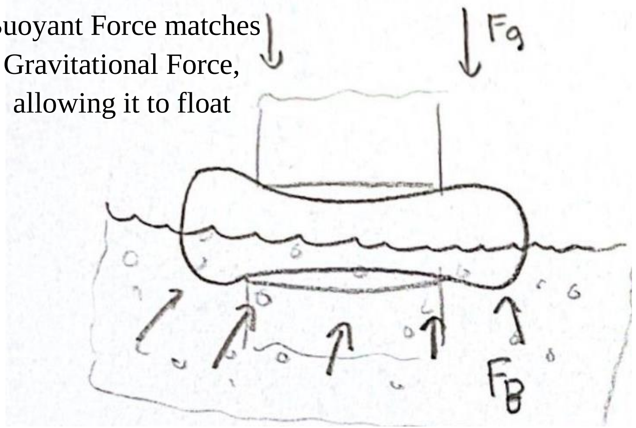


Isometric View

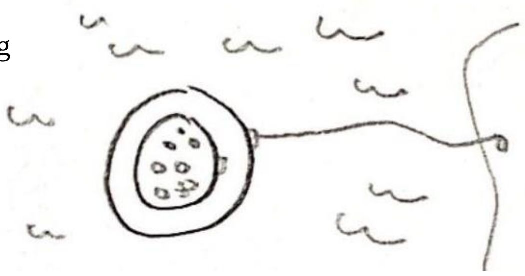
Clean water evaporating and falling back down around tube



Buoyant Force matches Gravitational Force, allowing it to float



Elastic cord keeps floating device in position

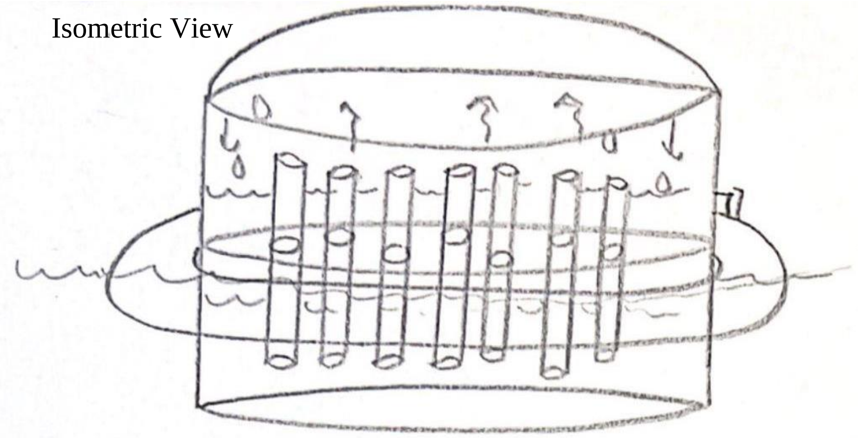


Pros:		Cons:	
MRC	Compact (relatively small surface area);	MRC	Away from home; Entire product needs to be carried from water source to home.
SC	Mobile (~20lbs), and always on the source.	TA	Long internal tubes make it fragile to transport (would need to have detachable components to add protective foam for transport)
CC	Composed mostly of biodegradable PLA material (lasting - inexpensive)	UR	Distills less than 1 gallon/day (the requirements for a single person). Needs a greater surface area. Difficult to clean/maintain without outside help
FR	Meets WQS drinking water standards	UR	Air-blown floatation device is immensely vulnerable and prone to maintenance.
FR	No storage necessary; Overflow of clean water does not disrupt the function (excess clean water will just spill back through the tubes into the dirty water)	MR	Open system; susceptible to environmental damage due to constant contact with water. Rubber inflatable material could be toxic to the surrounding environment upon decomposition.

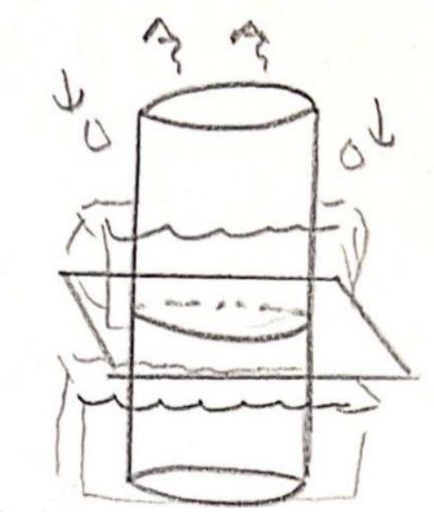
STAGE 1: Sketching & Designing

Design #4: "The Floating Saucer"

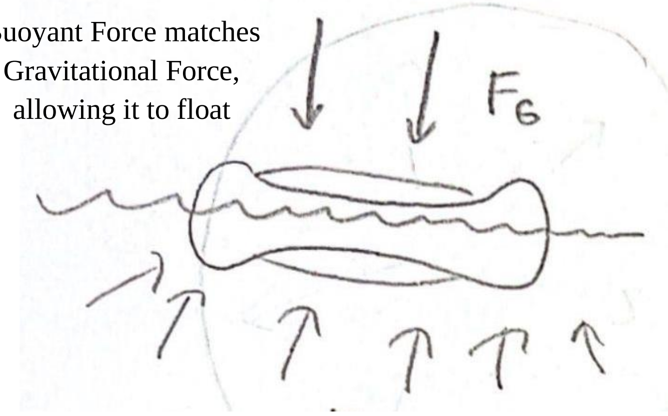
Isometric View



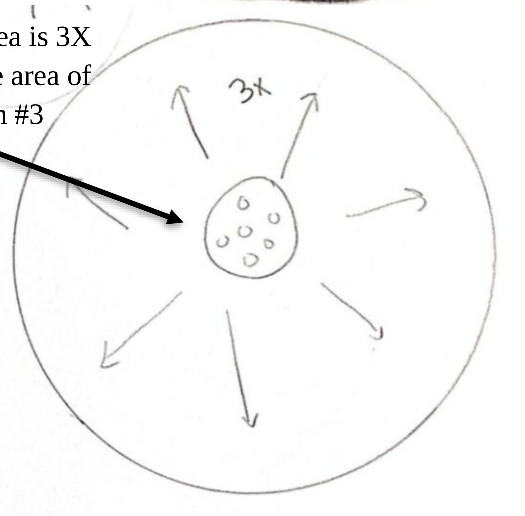
Clean water evaporating and falling back down around tube



Buoyant Force matches Gravitational Force, allowing it to float



Surface area is 3X the surface area of Design #3

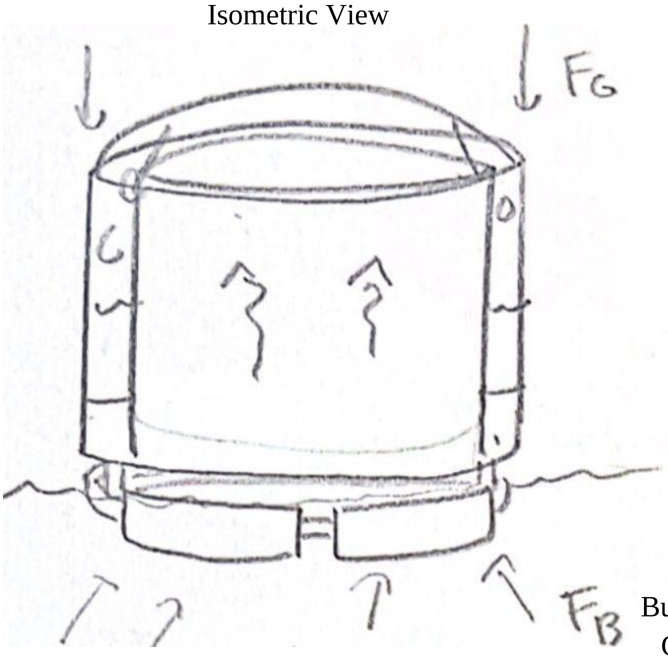


Pros:		Cons:	
UR	Distills 1 gallon/day (the requirements for a single person).	MRC	Away from home; Entire product needs to be carried from the water source to the home.
SC	Mobile (~20lbs), and always on the source.	TA	Long internal tubes make it fragile to transport (would need to have detachable components to add protective foam for transport)
CC	Composed mostly of biodegradable PLA material (lasting - inexpensive)	MRC	Extensive and heavy (Hard to pick up and transport back to the house)
FR	Meets WQS drinking water standards	UR	Air-blown floatation device is immensely vulnerable and prone to maintenance. Difficult to clean/maintain without outside help.
FR	No storage necessary; Overflow of clean water does not disrupt the function (excess clean water will just spill back through the tubes into the dirty water)	MR	Open system; susceptible to environmental damage due to constant contact with water. Rubber inflatable material could be toxic to the surrounding environment upon decomposition.

STAGE 1: Sketching & Designing

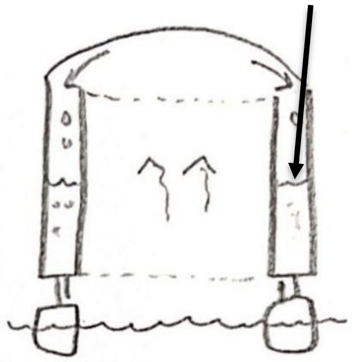
Design #5: "The Water Crockpot"

Isometric View



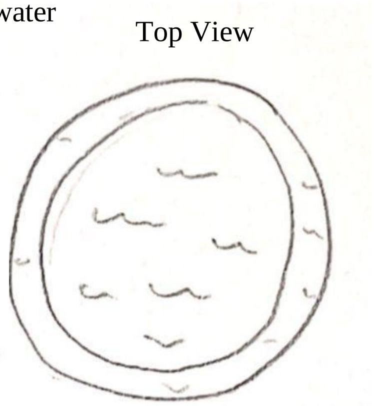
Buoyant Force matches Gravitational Force, allowing it to float

Clean water

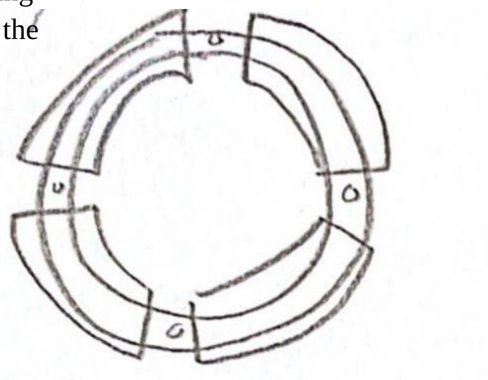


Clean water evaporating and sliding down into the circular collector

Top View



Bottom View

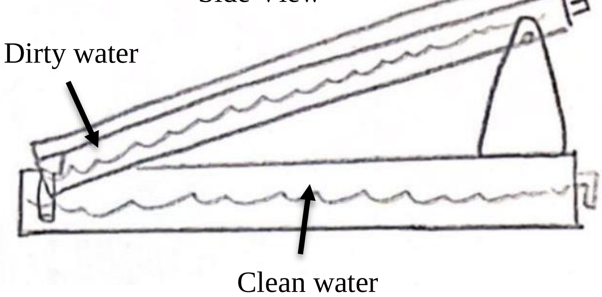


Pros:		Cons:	
MRC	Compact (relatively small surface area); Can be used above water (away from home) or above a container of dirty water (near the home)	UR	Distills less than 1 gallon/day (the requirements for a single person). Needs a greater surface area. Difficult to clean/maintain without outside help
SC	Mobile (~20lbs), and has the option to always be on source	MR	Open system; susceptible to environmental damage due to constant contact with water. Foam/plastic material could be toxic to the surrounding environment upon decomposition.
CC	Composed mostly of biodegradable PLA material (lasting - inexpensive)	M	Parts are not interchangeable (only using custom components)
FR	Meets WQS drinking water standards; No storage necessary; Overflow of clean water does not disrupt the function (excess clean water will just spill back through the tubes into the dirty water)		
UR	Foam floatation device requires little maintenance and cannot be naturally damaged		
TA	Easy to transport. The product is pretty consolidated and has no fragile components		

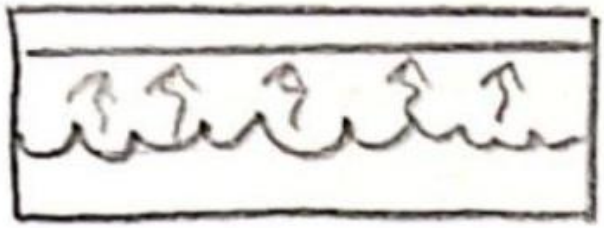
STAGE 1: Sketching & Designing

Design #6: “The Deck of Cards”

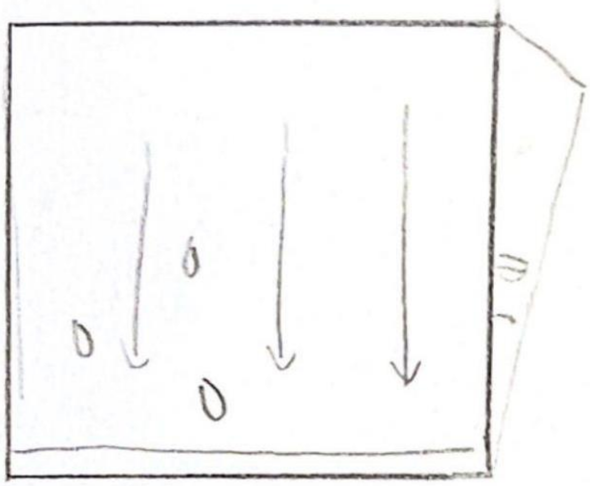
Side View



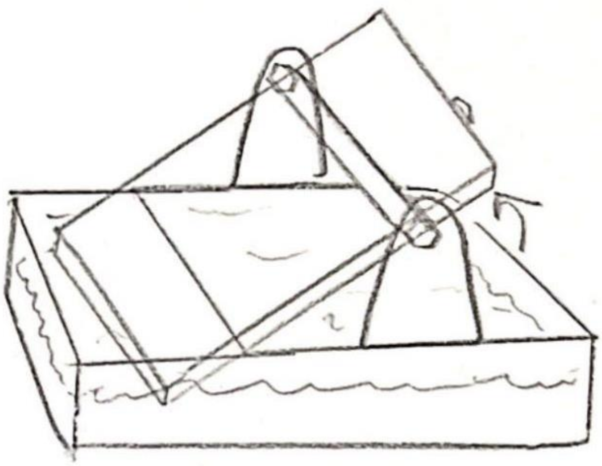
Dirty water evaporates and slides down into the clean water container.



Front View (Water droplets sliding down)



Isometric View

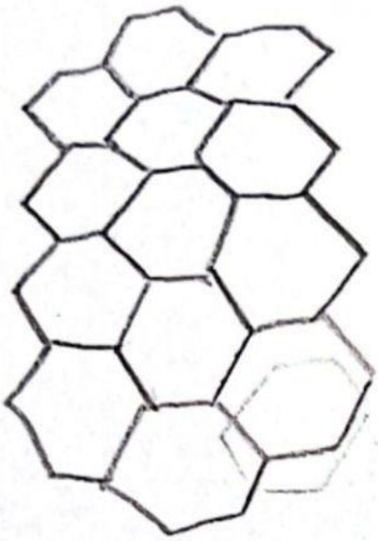


Pros:		Cons:	
UR	Distills 1 gallon/day (the requirements for a single person).	SC	Immobile (>40lbs) and large heavy dirty water compartment (away from the source)
CC	Composed mostly of biodegradable PLA material (lasting - inexpensive)	FR	Clean water container is open and susceptible to containment. Very small 1-gallon dirty water container.
FR	Meets WQS drinking water standards	MRC	Extensive and heavy (Hard/impossible to transport/adjust without help)
FR	Huge 4-5 gallon clean water storage.	MR	Open system; susceptible to environmental damage due to constant contact with water. Rubber inflatable material could be toxic to the surrounding environment upon decomposition.

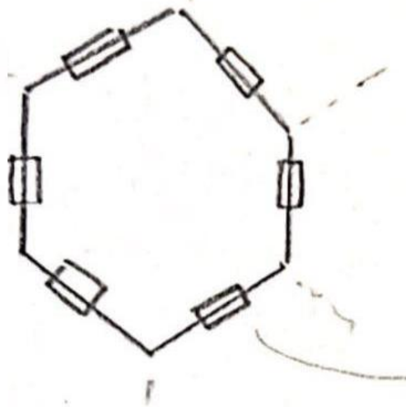
STAGE 1: Sketching & Designing

Design #7: “The Hexagon Blanket”

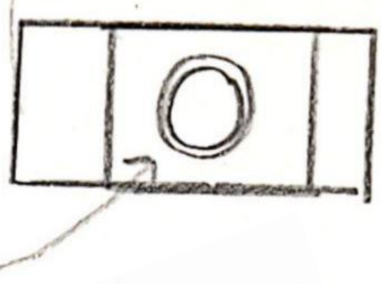
Connected sheet of designs



Top View

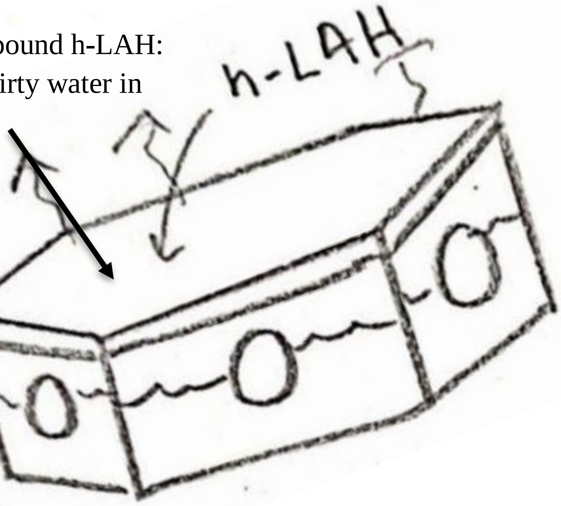


Side View

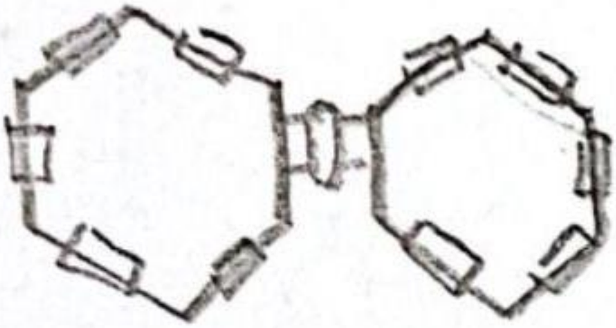


Isometric View

Layer of chemical compound h-LAH: Evaporates/cleanses dirty water in container.



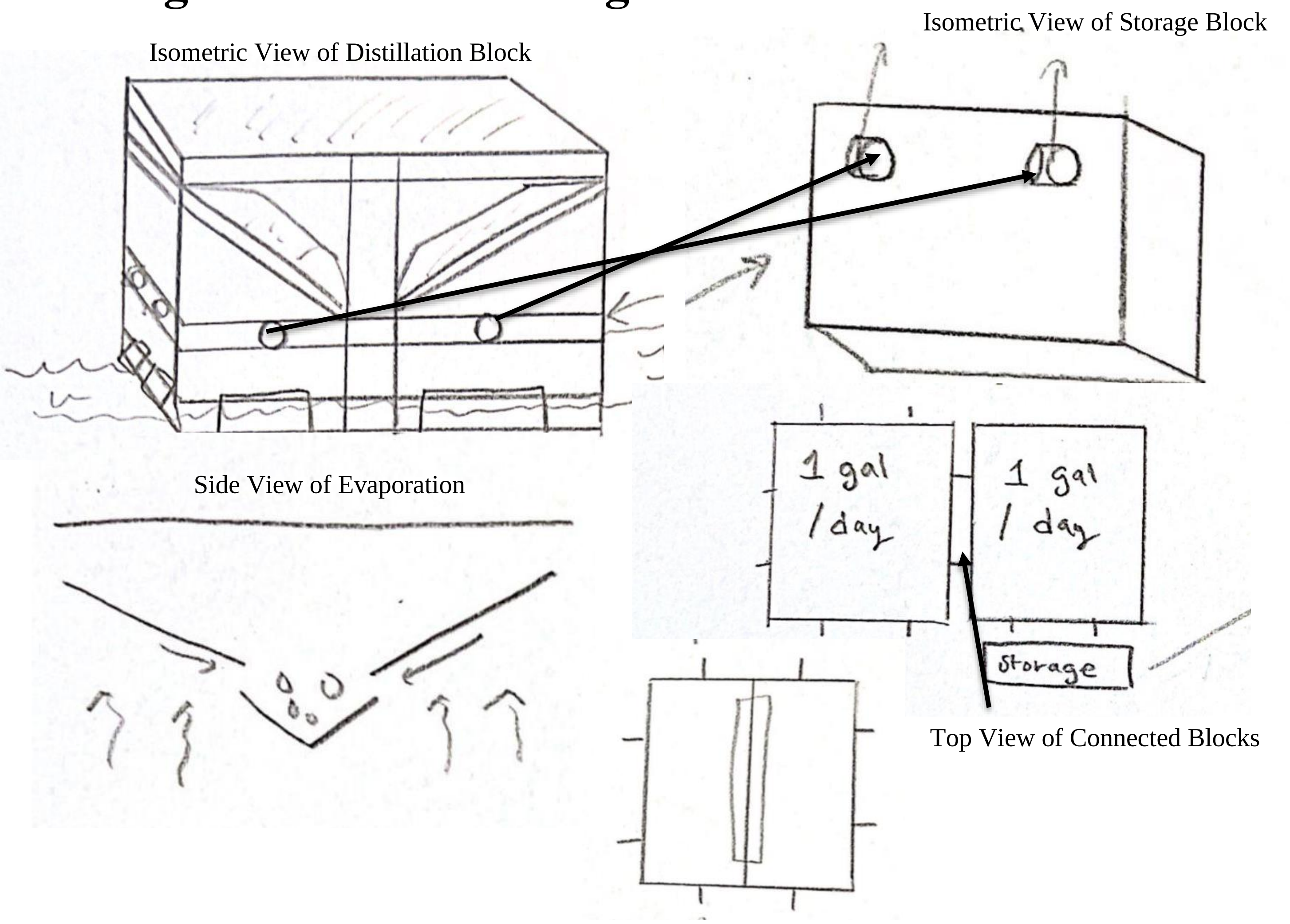
Two hexagon designs connected



Pros:		Cons:	
MRC	Compact (relatively small surface area), and compartmentalized all-in-one system for the house (easy to access clean water)	SC	Mobile but the water takes time to distill and it is hard to determine when the water is finished distilling.
MR	Closed system; resistive to environmental elements	MR	Chemical layer (h-LAH) can be extremely dangerous, upon leaking, to the surrounding environment.
CC	Composed of biodegradable PLA material (lasting - inexpensive)	UR	Difficult to clean/maintain without outside help
FR	Meets WQS drinking water standards with Expandable storage	UR	The whole sheet needs to be carried from the source of dirty water back to the home every use.
UR	Distills as much water as needed		

STAGE 1: Sketching & Designing

Design #8: "The Building Blocks"

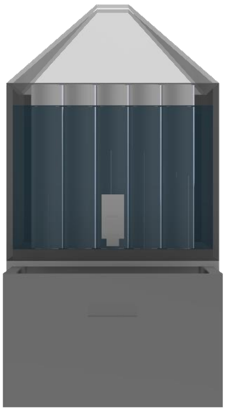


Pros:		Cons:	
MRC	Compartmentalized. Can be used above water (away from home) or above a container of dirty water (near the home)	MR	Open system; susceptible to environmental damage due to constant contact with water. Foam/plastic material could be toxic to the surrounding environment upon decomposition.
CC	Composed of biodegradable PLA material (lasting - inexpensive)	UR	Detachable container needs to be moved from place to place for every refill (difficult if installed at a source of dirty water)
FR	Meets WQS drinking water standards with Expandable storage		
SC	Mobile (~25lbs when empty), and has the option to always be on source		
UR	Distills 1 gallon/day (the requirements for a single person). Easy to clean		
M	Parts are interchangeable (piping)		

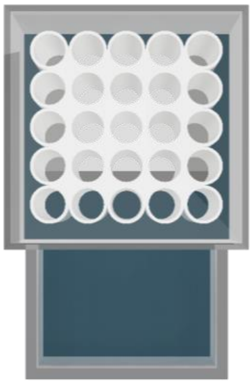
STAGE 2: Further Developing the Design

Design #1: "The Skyscraper"

Front View

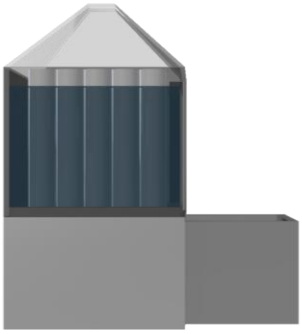


Top View

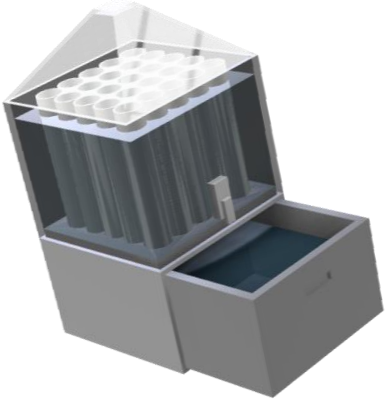


Isometric View of Dirty Water Drawer

Side View



Isometric View

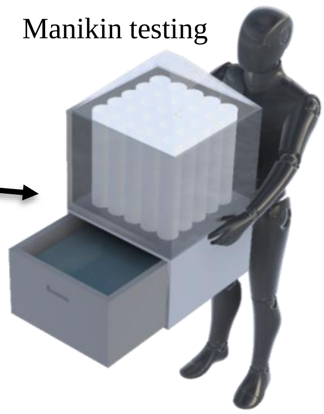


Challenges & Solutions in Regards to Specifications:	
M	The bottom drawer and housing are manufactured using biodegradable PLA material while the top material is manufactured using plexiglass. The internal piping is also composed of PLA.
UR	The bottom compartment can store a maximum of ~1.5 gallons while the top component can store ~2 gallons according to the material volume retrieved from designs in Fusion360
MR	Waterproof adhesives (ex. Industrial Adiseal adhesive) used to seal the plexiglass upper half to the bottom storage container.

Evaluation of Model:

- This model passes the mobility test by falling under 30lbs, by Fusion360 material estimates, and falls within the 5th percentile wingspan (covers the 5th-95th percentile for adults 18-60 transportation). Arm length 5th-95th percentile— 40cm to 55cm

Manikin testing



Manikin testing for drawer

Additional Research

From Personal Distillation Experiment:

- According to my personal experiment (looking at roughly 0.025 m^2 of light), this model, given its surface area, should produce 0.462 gal/day

Expert Jayson Bryson ("The Water Project"):

- This model should meet WQS drinking water standards while taking the necessary steps to avoid contamination.
- They expressed concerns about this specific model's ability to serve a family at its distillation rate. "It doesn't justify its use by a non-profit"

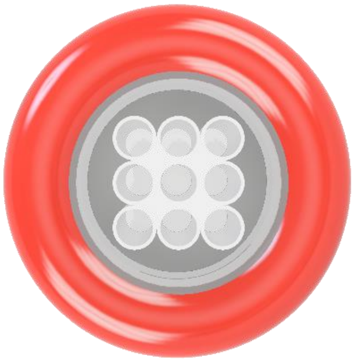
```
Approximate Weight (Body 13):
12.45 lbs
Approximate Weight (Body 13 w/ Water):
41.74 lbs
```

STAGE 2: Further Developing the Design

Design #3: “The Floating Trash Can”

Isometric View

Top View



Side View

Bottom View

Challenges & Solutions in Regards to Specifications:	
M	The Inflatable tube was designed to be blown up with the human mouth so that the product would not need maintenance. In addition, the top lens was made flat to avoid wind/water damage while still focusing light and dispersing evaporation to the edges of the circle.
UR	The top component can store ~2 gallons according to the material volume retrieved from designs in Fusion360. The bottom is dependent upon the body of water it is in.
MR	Waterproof adhesives (ex. Industrial Adiseal adhesive) are used to seal the plexiglass upper half to the bottom storage container.

Evaluation of Model:

- This model passes the mobility test by falling under 30lbs, by Fusion360 material estimates, and falls within the 5th percentile wingspan (covers the 5th-95th percentile for adults 18-60 transportation). Arm length 5th-95th percentile—40cm to 55cm

Additional Research:

From Personal Distillation Experiment:

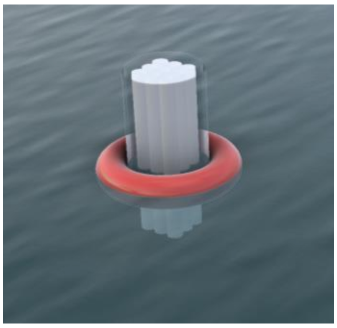
- According to my personal experiment (looking at roughly 0.025 m^2 of light), this model, given its surface area, should produce 0.386 gal/day

Expert Jayson Bryson (“The Water Project”):

- This model should meet WQS drinking water standards while taking the necessary steps to avoid contamination.
- They expressed concerns about this specific model’s ability to serve a family at its distillation rate. “It doesn’t justify its use by a non-profit”

Manikin testing

Design in Water



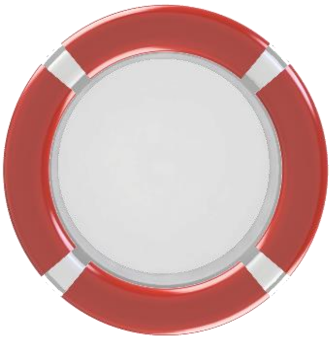
```
Approximate Weight (Body 9):
11.22 lbs
Approximate Weight (Body 9 w/ Water):
28.13 lbs
```

STAGE 2: Further Developing the Design

Design #5: “The Water Crockpot”

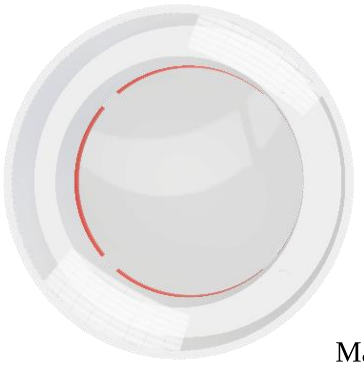
Side View

Bottom View



Isometric View

Top View



Challenges & Solutions in Regards to Specifications:	
M	The top component is made of PLA. The bottom red floatation components are made of foam and the top lens is made of plexiglass.
UR	The top component can store ~1 gallon according to the material volume retrieved from designs in Fusion360. The bottom is dependent upon the body of water it is in.
MR	Waterproof adhesives (ex. Industrial Adiseal adhesive) are used to seal the plexiglass upper half to the bottom storage container.

Evaluation of Model:
• This model passes the mobility test by falling under 30lbs, by Fusion360 material estimates, and falls within the 5th percentile wingspan (covers the 5th-95th percentile for adults 18-60 transportation). Arm length 5th-95th percentile—40cm to 55cm

Additional Research:

From Personal Distillation Experiment:

- According to my personal experiment (looking at roughly 0.025 m^2 of light), this model, given its surface area, should produce 0.594 gal/day

Expert Jayson Bryson (“The Water Project”):

- This model should meet WQS drinking water standards while taking the necessary steps to avoid contamination.
- They expressed concerns about this specific model’s ability to serve a family at its distillation rate. “It doesn’t justify its use by a non-profit”

Manikin testing

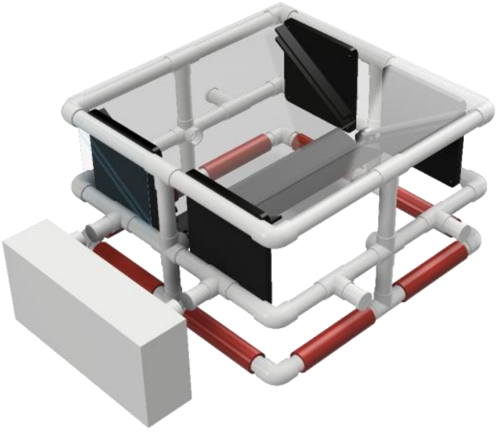
Design in Water

```
Approximate Weight (Body 6):
5.79 lbs
Approximate Weight (Body 6 w/ Water):
14.29 lbs
```

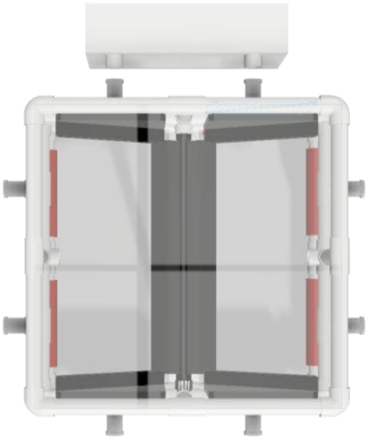
STAGE 2: Further Developing the Design

Design #8: "The Building Blocks"

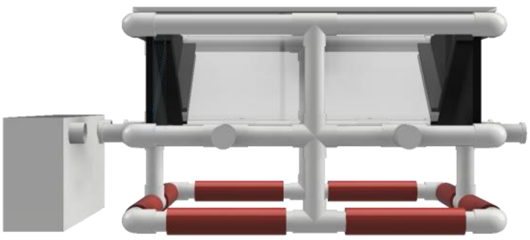
Isometric View



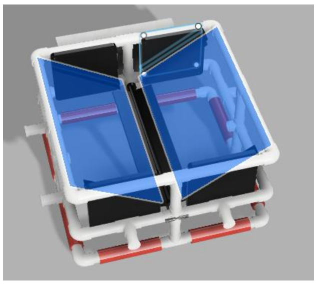
Top View



Side View



Highlighted Side Plexiglass Evaporation "catchers"



Challenges & Solutions in Regards to Specifications:	
M	The piping is made out of PLA (as opposed to toxic PVC production). The custom-angled plexiglass holders and the external container are made of 3D-printed PLA. The top protective plate and the two angled evaporation "catchers" are made from plexiglass. The floatation device is foam.
UR	The "green" (clean water) component can store ~2 gallons in one unit plus a storage tank according to the material volume retrieved from designs in Fusion360
MR	Waterproof adhesives (ex. Industrial Adiseal adhesive) used to seal the plexiglass to the bottom storage container.

Evaluation of Model:

- This model passes the mobility test by falling under 30lbs, by Fusion360 material estimates, and falls within the 5th percentile wingspan (covers the 5th-95th percentile for adults 18-60 transportation). Arm length 5th-95th percentile— 40cm to 55cm

Additional Research:

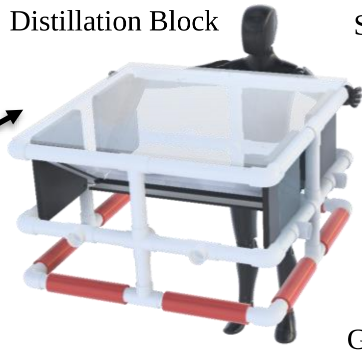
From Personal Distillation Experiment:

- According to my personal experiment (looking at roughly 0.025 m^2 of light), this model, given its surface area, should produce 1.24 gal/day

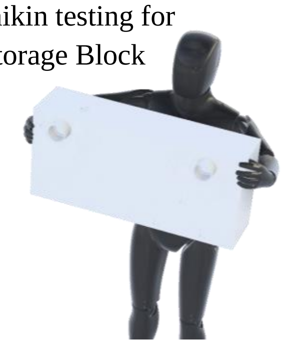
Expert Jayson Bryson ("The Water Project"):

- This model should meet WQS drinking water standards while taking the necessary steps to avoid contamination.
- They expressed concerns about this specific model's wireframe design but did say it blended in as a water-based utility.

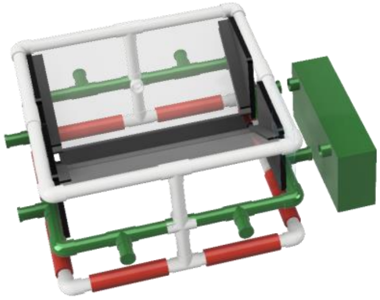
Manikin testing for Distillation Block



Manikin testing for Storage Block



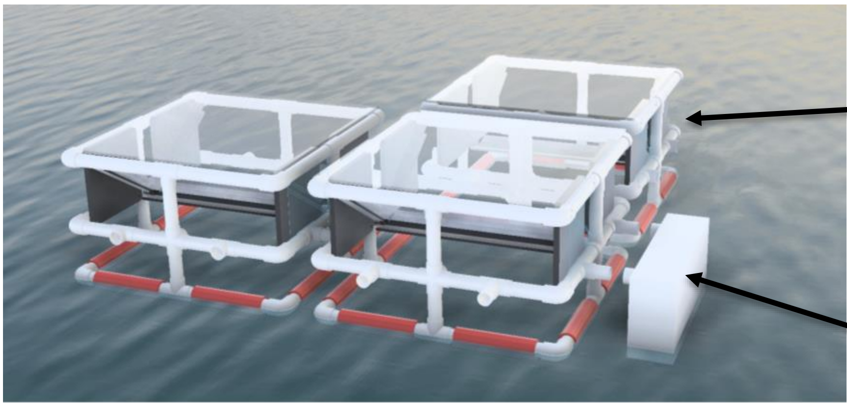
Green Part = Area where clean water is stored



```
Approximate Weight (Body 17):
15.41 lbs
Approximate Weight (Body 17 w/ Water):
32.49 lbs
```

STAGE 3: Finalizing Design Selection

(Chosen) Design #8: "The Building Blocks"



Key Features

- Compartmentalized water distillation: expandable based on family size.
- Multi-purpose: Can be used on land (with a water container underneath) and in water.
- Detachable (light) clean water storage.

Justification of Chosen Design (#8) Based on Specification	
TM	This design is heavily compartmentalized to maximize the potential clean water output for a family. Designed for outside/water use as well as in robust environments.
TA	The product is designed to be mobile, and its affordance is simplistic due to the frame design that makes its function rather obvious. No language barriers and the setup are permanent with the exception of the lightweight storage container that minimizes necessary transport.
UR	Distills >1 gallon/day (the requirements for a single person). In addition, its framework design allows it to be easy to clean without outside maintenance.
MRC	It addresses a wide variety of use cases/competition through its ability to be used above water (away from home) or above a container of dirty water (near the home)
FR	Meets WQS drinking water standards with expandable storage; (unlimited/no dirty water storage)
AR	According to Expert Jayson Bryson, this design fits in with other water filtration devices, maintaining a consistent profile amongst other daily applications.
MR	The piping is made from PLA (as opposed to toxic PVC production). The custom-angled plexiglass holders and the external container are made of 3D-printed PLA. The top protective plate and the two angled evaporation "catchers" are made from plexiglass. The floatation device is foam. Most of these materials are biodegradable, minimizing the negative environmental impact.
SC	This model passes the mobility test by falling under 30lbs, by Fusion360 material estimates, and falls within the 5th percentile wingspan. These approximations were made with an arm length i in the 5th-95th percentile of adults aged 18-60 (40cm to 55cm)
CC	Composed of biodegradable PLA material, foam, and plexiglass (lasting - inexpensive). In accordance with PLA price calculator[1], as well as the prices of other components, this design costs less than $200 to produce (meeting the original specification).
M	Piping components are interchangeable (piping); Common manufacturing processes.

[1] Szyk, B. (2022, October 19). 3D Printing Cost Calculator. https://www.omnicalculator.com/other/3d-printing

Material Justification:

<table>
<tr><td>Material</td><td>Biodegradable PLA (eventual replacement for PVC piping used in prototype)</td><td rowspan="3">The PLA piping acts as a function of both structures as well as, in the middle layer, storage for clean water. The panel/lens holders are used to attach the panels to the piping structure which requires durability and strength that will last the product through its desired lifecycle (~10 years).</td></tr>
<tr><td>Component</td><td>Support & functional/storage piping as well as the custom lens panel holders (A-F, H, K)</td></tr>
<tr><td>Physical/ working properties</td><td>High Tensile Strength
Smooth texture
Does not absorb water / Repels water</td></tr>
<tr><td>Environmental properties</td><td>Sustainable production
Biodegradable
Durable</td><td>PLA is highly durable and a known biodegradable material, with a life of 10+ (12 to 18) years, and more once protected with a further coating. This means less waste is produced. 3D printing also allows for a high volume of production and is sustainable to its surrounding environment. In addition, the material is completely biodegradable and recyclable towards the end of the product life cycle.</td></tr>
<tr><td>Aesthetic properties</td><td>Color can be customized to the match environment</td><td>Through the use of different PLA filaments, the manufacturer can shift between different shades of green, navy, and grey to match its surrounding environment and retain an attractiveness that would only attribute to the product’s mass adoption. It can also be painted in a protective coating that furthers the longevity of the material by anywhere from 5-10 additional years.</td></tr>
</table>

<table>
<tr><td>Material</td><td>PVC (will not be used in final production)</td><td rowspan="3">The PVC piping acts as a function of both structures as well as, in the middle layer, storage for clean water.</td></tr>
<tr><td>Component</td><td>Support & functional/storage piping as well as the custom lens panel holders (A-F, H, K)</td></tr>
<tr><td>Physical/ working properties</td><td>High Tensile Strength
Smooth texture
Does not absorb water / Repels water</td></tr>
<tr><td>Environmental properties</td><td>Durable</td><td>PVC is highly durable, with a life of 10+ (12 to 18) years, and more once protected with a further coating. This means less waste is produced</td></tr>
<tr><td>Aesthetic properties</td><td>Color can be customized to the match environment</td><td>Through the use of different PVC filaments, the manufacturer can shift between different shades of green, navy, and grey to match its surrounding environment and retain an attractiveness that would only attribute to the product’s mass adoption. It can</td></tr>
</table>

		also be painted in a protective coating that furthers the longevity of the material by anywhere from 5-10 additional years.

Material	Plexiglass (Methyl Methacrylate)	The panels/lenses that direct sunlight rays onto the water beneath need to be apparently clear for visual inspection and function efficiency. Plexiglass was chosen because it fulfills both of these objectives while also providing the strength to serve as the protective cover for the product.
Component	The functional (ray-directing) lenses and the protective top cover (I & J)	
Physical/ working properties	● High tensile strength ● Smooth texture ● Does not absorb water / Repels water ● Can be cut to custom sizes/dimensions ● Solid allowing light rays through	
Environmental properties	● Sustainable production ● Recyclable ● Durable	The material is completely recyclable towards the end of the product life cycle.
Aesthetic properties	● Maximum transparency	The transparency of the panels allows users to look through the product from the top and analyze any possible damage/capacity issues that may arise.

Material	Polyethylene	The Polyethylene foam bottom borders act as a function for keeping the device floating above the water. The high buoyancy (and high buoyancy life cycle) of the material makes it desirable because it allows the device to remain in function, without disruption, for 10+ years while also being replaceable upon a request for maintenance.
Component	Bottom foam tubes for floatation (G)	
Physical/ working properties	● High Buoyancy ● Porous ● Smooth on the outside ● Limited water damage.	
Environmental properties	● Sustainable production ● Biodegradable ● Durable ● Recyclable ● Removable (easy-to-repair)	Polyethylene is highly durable and a known biodegradable material, with a life of 10+ (22-30) years, and more once protected with a further coating. This means less waste is produced. In addition, the material is completely biodegradable and recyclable towards the end of the product life cycle. In addition, the material is completely biodegradable and recyclable towards the end of the product life cycle.
Aesthetic properties	● Color can be customized to match the environment	Through the use of different Polyethylene filaments, the manufacturer can shift between different shades of green, navy, and grey to match its surrounding environment and retain an attractiveness that would only attribute to the product’s mass adoption. It can also be painted in a protective coating that furthers the longevity of the material by anywhere from 5-10 additional years.

Manufacturing Justification:

Component	**Manufacturing Technique**	**Justification**
Support & functional/storage piping as well as the custom lens panel holders (A-F, H, K)	1. 3D FDM/SLA Printing (depending upon the size of the pipe) 2. Surface Curing	This material can be additively composed into complex shapes. This technique also offers limited waste and always achieves the right dimensions. Curing techniques also ensure the smoothness of the outer material and, in turn, contributes to the mobility of the product when moving it from place to place.
The functional (ray-directing) lenses and the protective top cover (I & J)	1. Band Saw 2. Drill press 3. Finishing/Polishing edges	The use of precise and individual manufacturing techniques allows for the panels to be cut to the exact dimensions. This process also allows humans to directly analyze the transparency of the plexiglass.
Bottom foam tubes for floatation (G)	1. 3D FDM Printing (depending upon the size of the pipe) 2. Material Finishing	This material can be additively composed into complex shapes. This technique also offers limited waste and always achieves the right dimensions. This technique also allows for flexibility and easy adjustments to the porous nature of the material which grants the product its buoyancy.

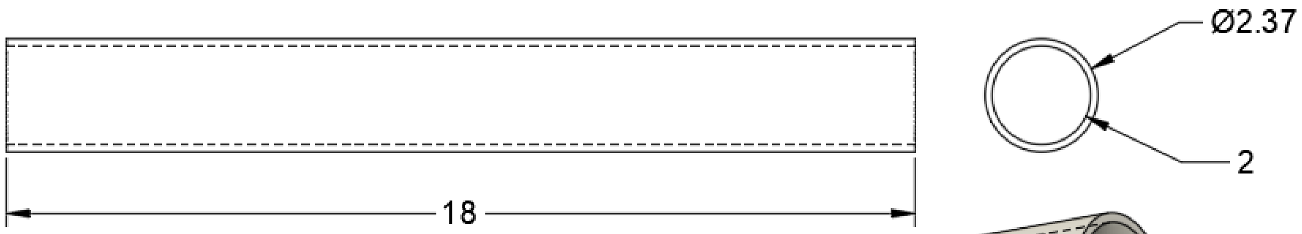
Part Breakdown:

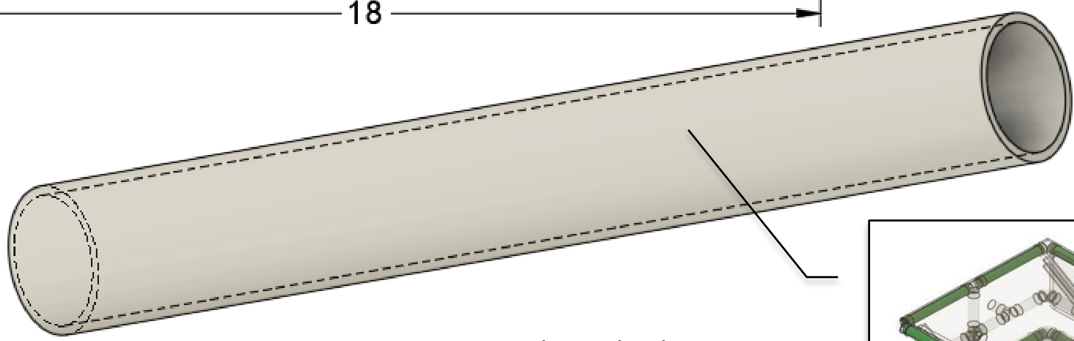
Part		Material Volume Approx.	Material	(External - Internal) Radius	Quantity
A	18” - 2” Piping	19 in^3	PVC (Eventually PLA Plastic)	0.37”	16
B	9” - 2” Piping	10.9 in^3	PVC (Eventually PLA Plastic)	0.37”	8
C	6” - 2” Piping	8.4 in^3	PVC (Eventually PLA Plastic)	0.37”	16
D	R-Tee 2” Piping	14.45 in^3	PVC (Eventually PLA Plastic)	0.37”	16
E	Elbow 2” Piping	12.4 in^3	PVC (Eventually PLA Plastic)	0.37”	12
F	3-Axis 2” Piping	18 in^3	PVC (Eventually PLA Plastic)	0.37”	4
G	14” - 2.4” Foam Tubing	20 in^3	Polyethylene	0.82”	8
H	Plate Holder	261.9 in^3	PLA Plastic	Not Applicable	2 (Both left and right orientation provided in each)
I	Plexiglass Plates	876.4 in^3	Plexiglass		2
J	Plexiglass Roofing	924.5 in^3	Plexiglass		1
K	Basin-2” Piping	181.9 in^3	PVC (Eventually PLA Plastic)	0.37”	1

Part diagrams—All measurements in inches

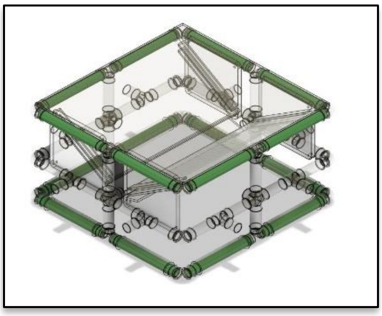
Part A: 18” - 2” Piping

Orthographic Projections



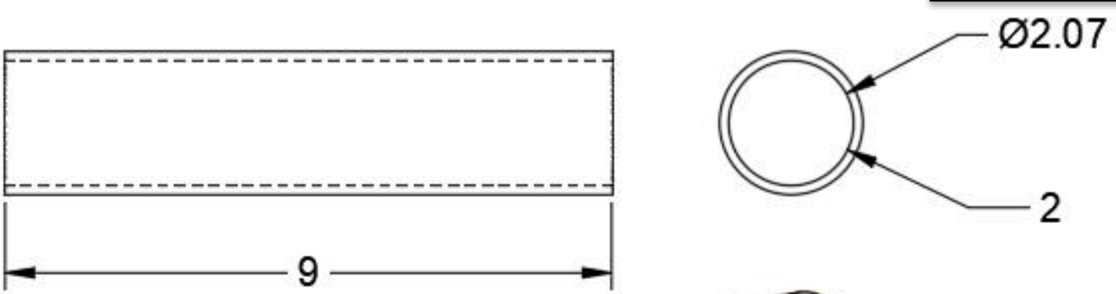


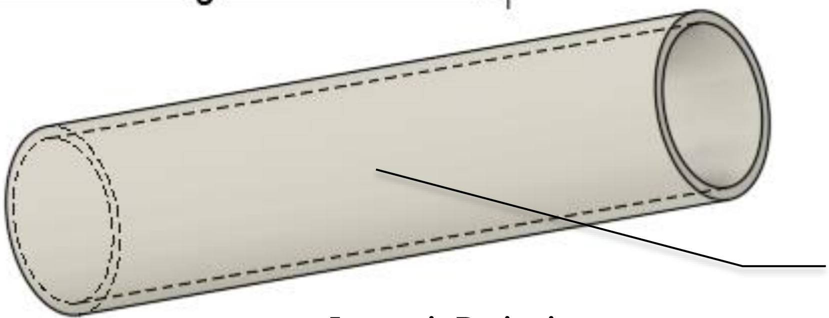
Isometric Projection



Part B: 9” - 2” Piping

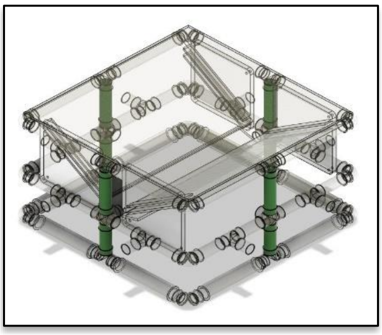
Orthographic Projections





Isometric Projection

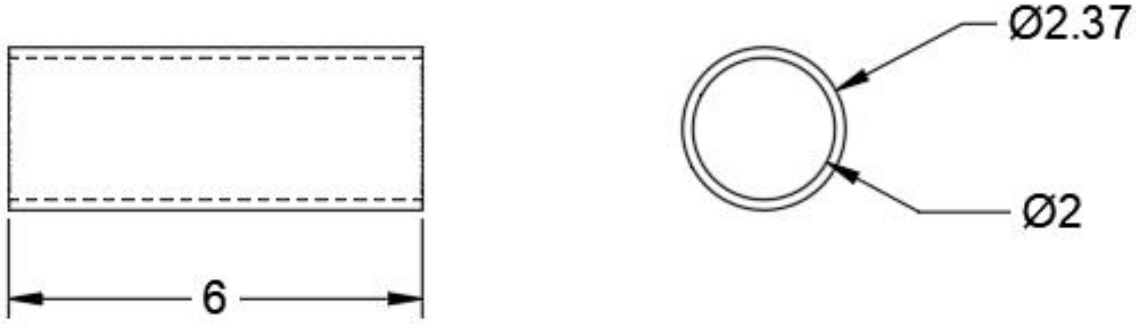
Larger Picture:

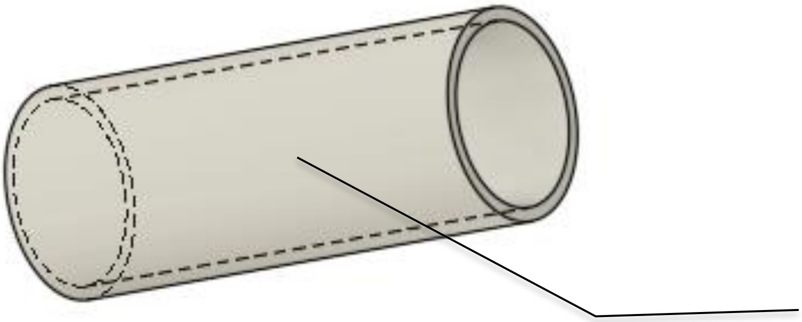


Scale: 1:2

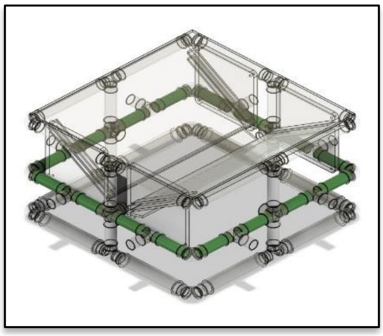
Part C: 6” - 2” Piping

Orthographic Projections





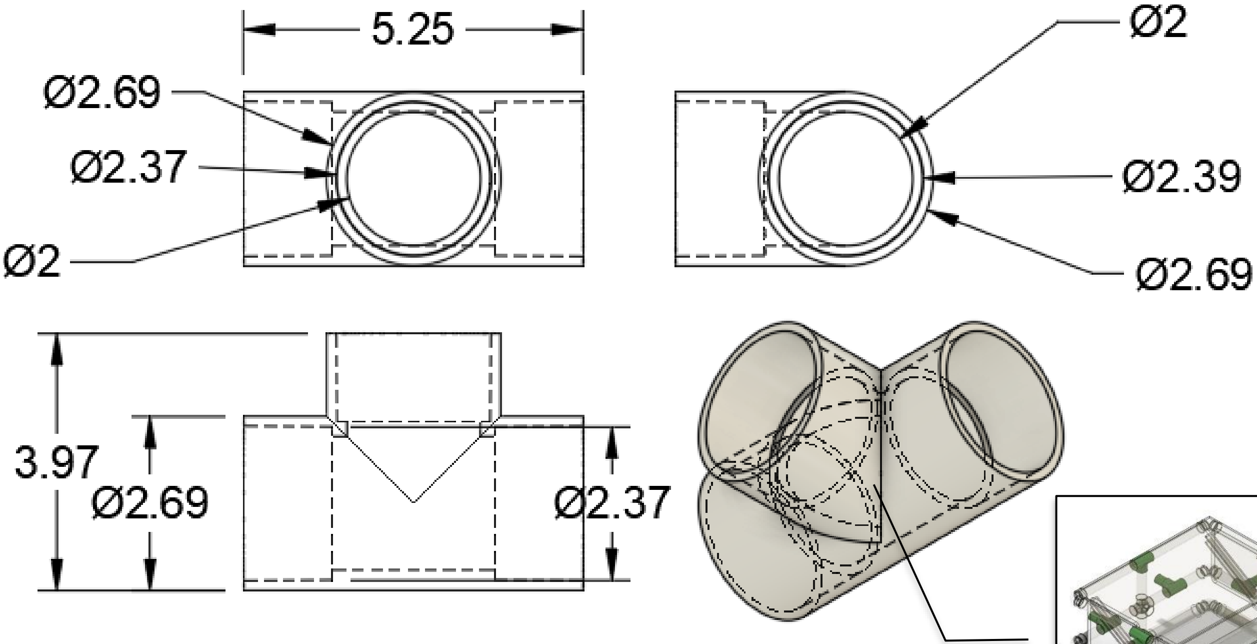
Isometric Projection

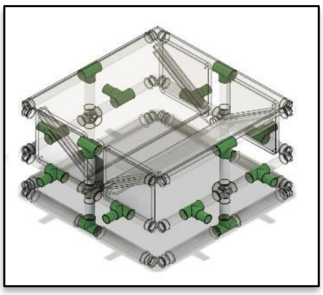


Part D: R-Tee 2” Piping

Scale: 1:2

Orthographic Projections



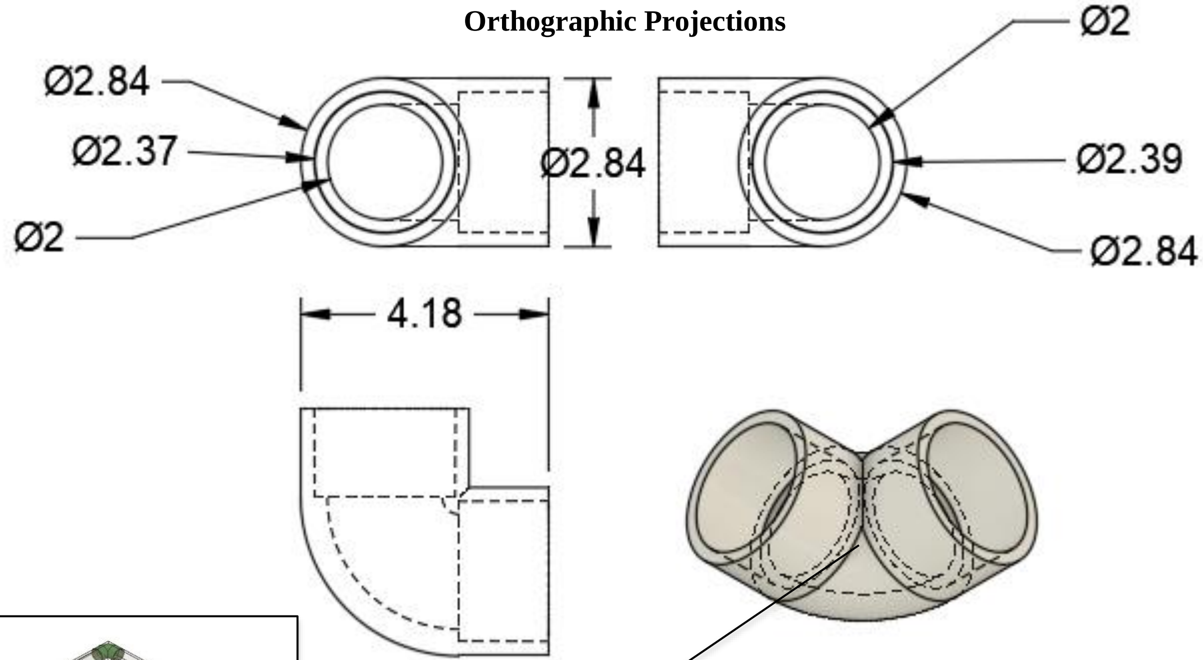


Isometric Projection

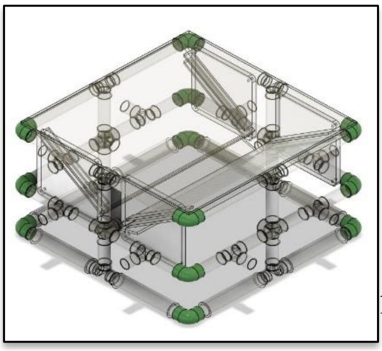
Part E: Elbow 2” Piping

Scale: 1:2

Orthographic Projections



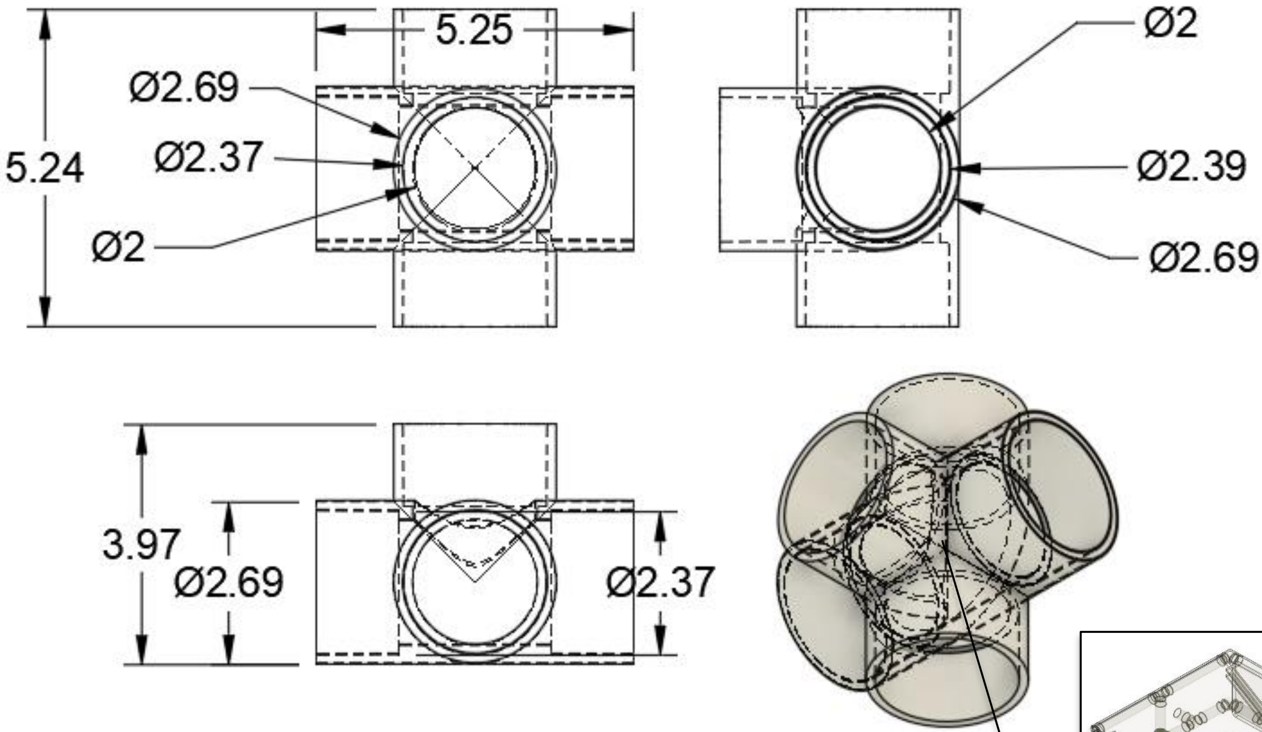
Isometric Projection



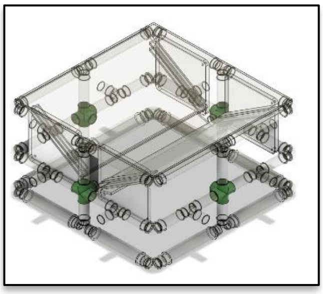
iping

Scale: 1:2

Orthographic Projections



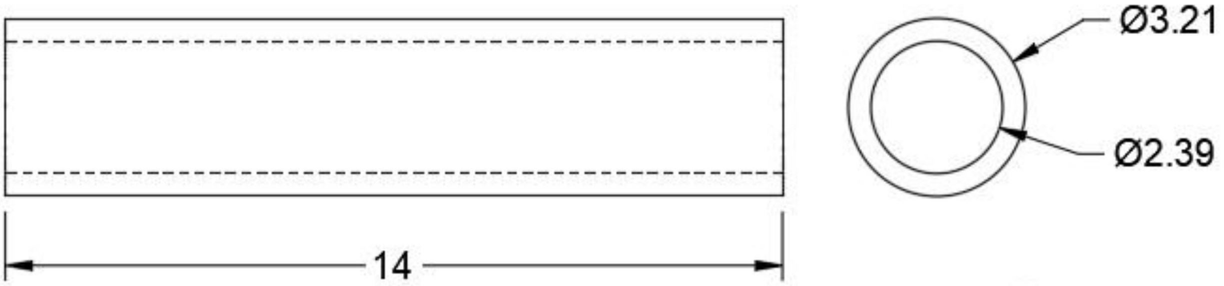
Isometric Projection

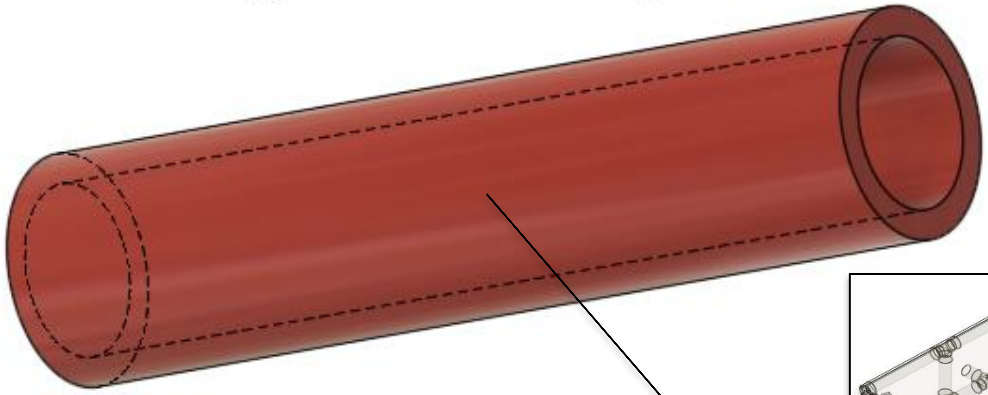


Part G: 14" - 2.4" Foam Tubing

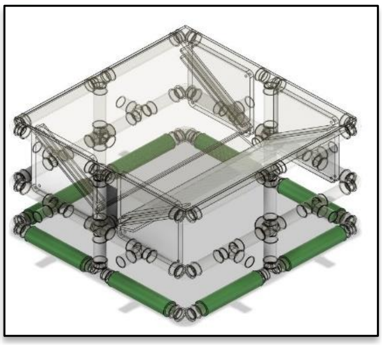
Scale: 1:2

Orthographic Projections





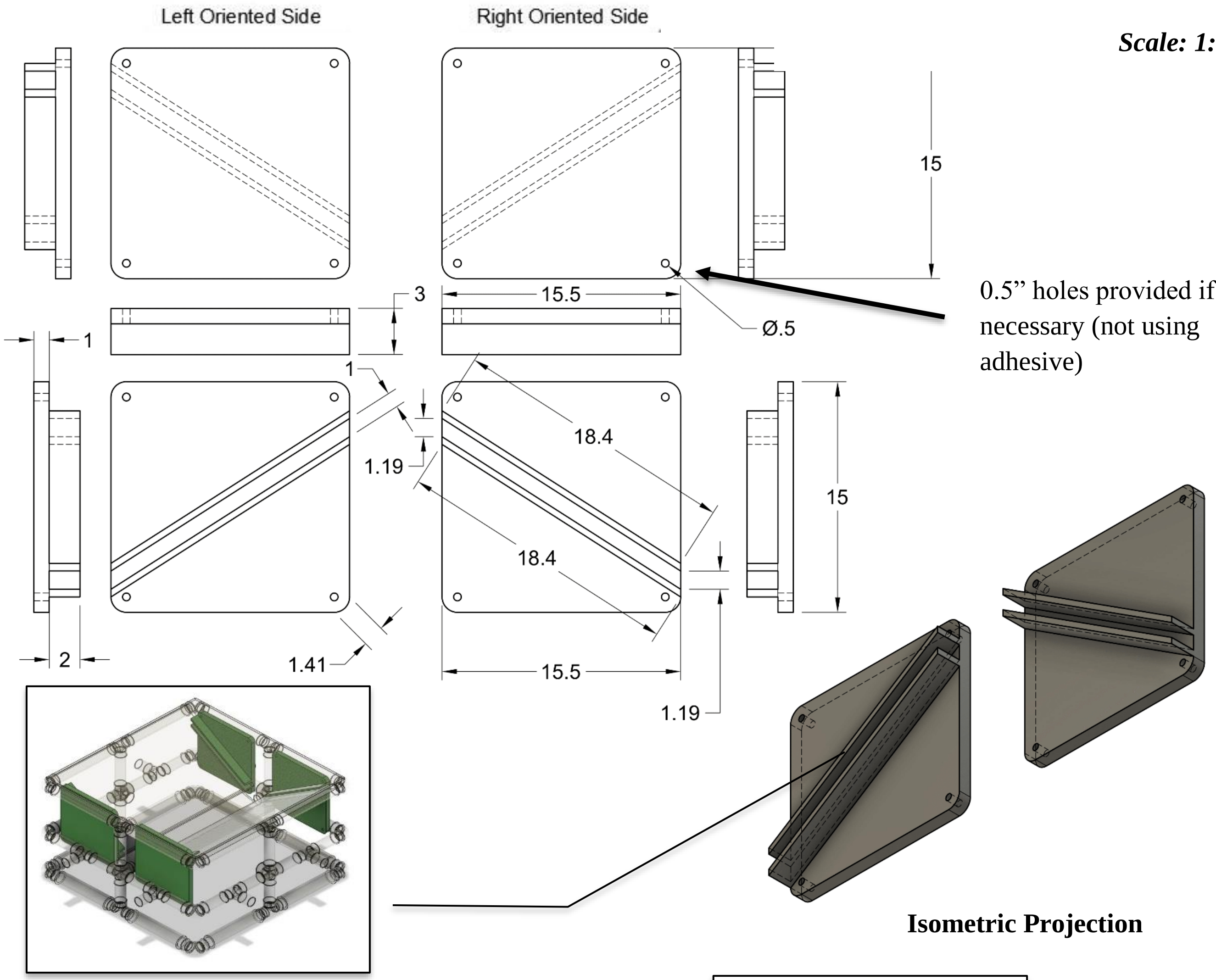
Isometric Projection



Part H: Plate Holder

Orthographic Projections

Scale: 1:4

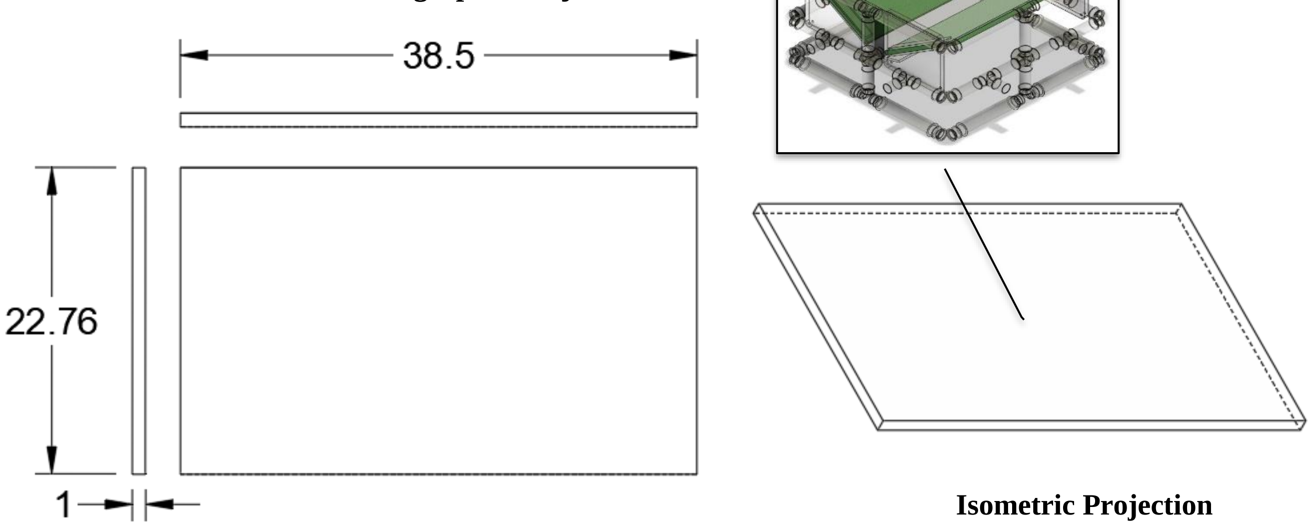


Isometric Projection

Part I: Plexiglass Plates

Orthographic Projections

Scale: 1:4

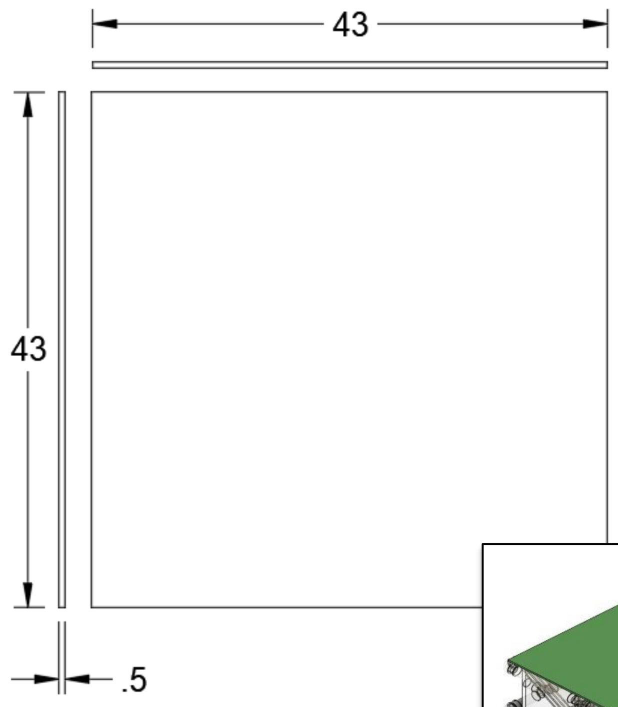


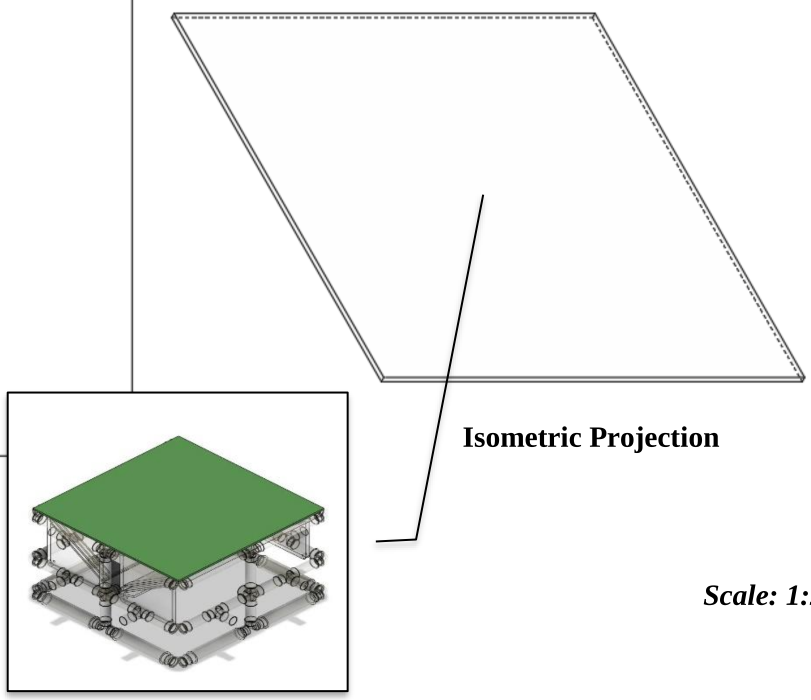
Isometric Projection

Part J: Plexiglass Roofing

Scale: 1:4

Orthographic Projections



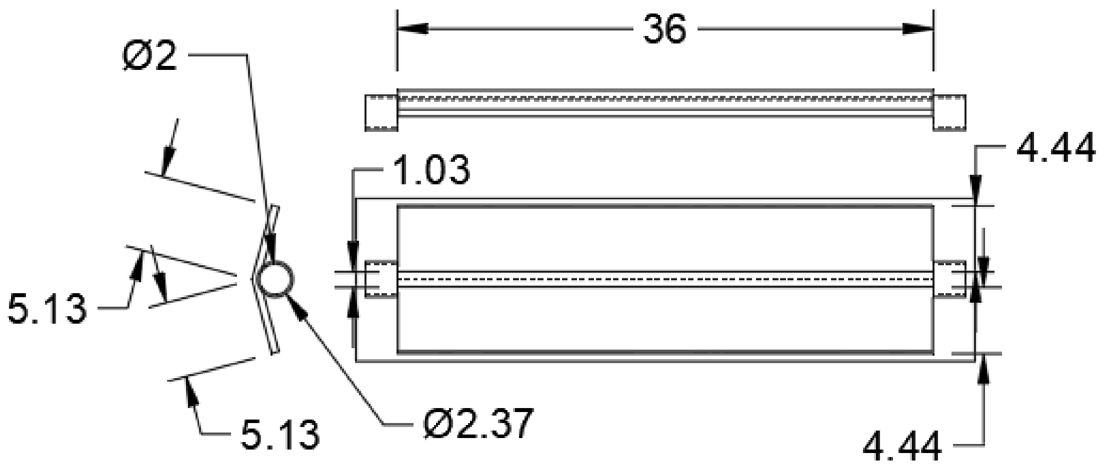


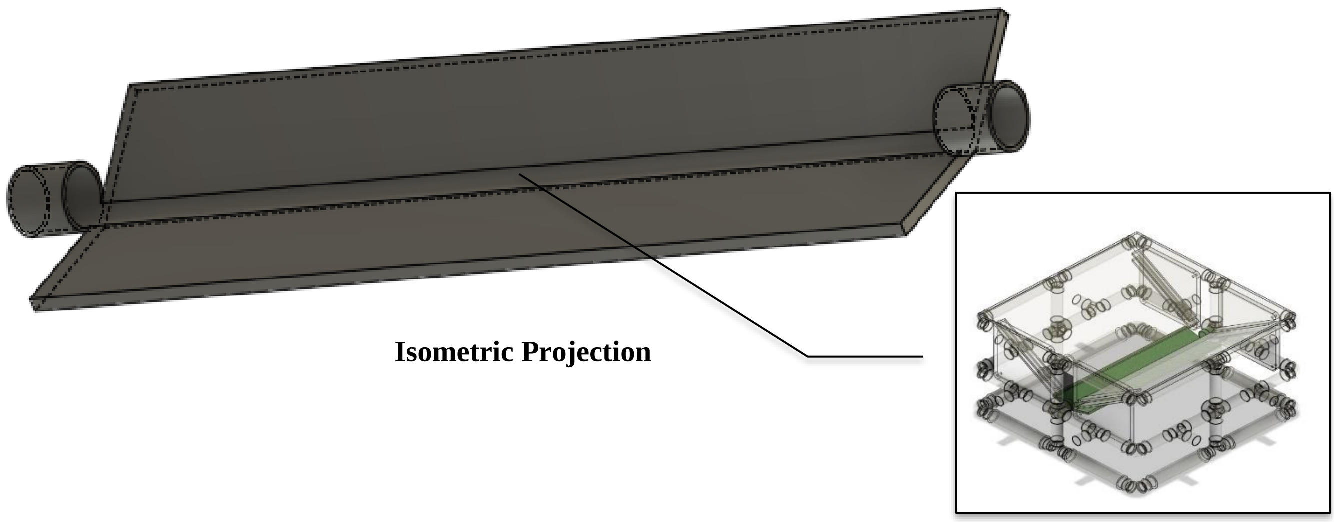
Isometric Projection

Part K: Basin-2” Piping

Scale: 1:2

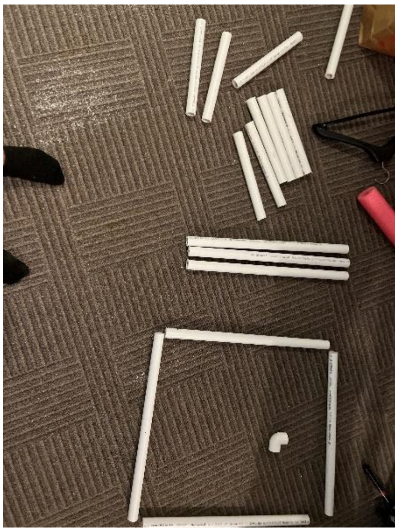
Orthographic Projections

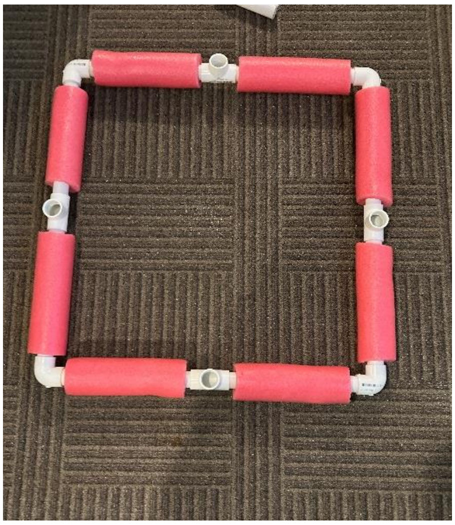




Isometric Projection

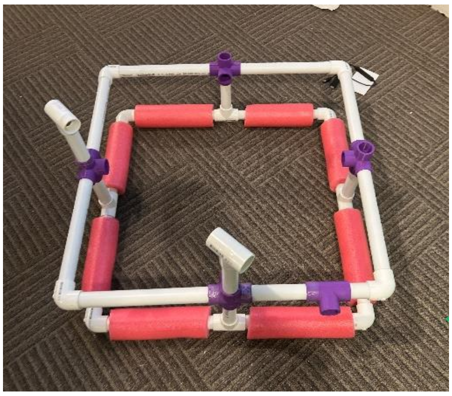
Prototype Development:



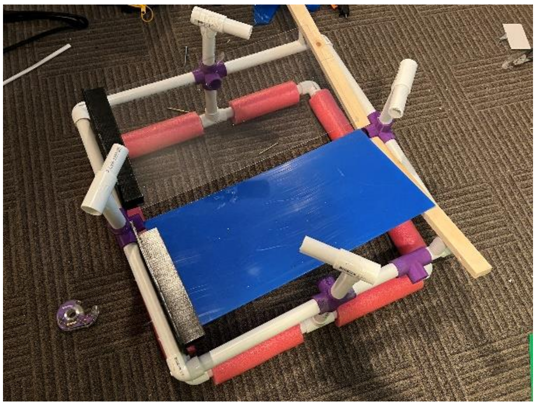


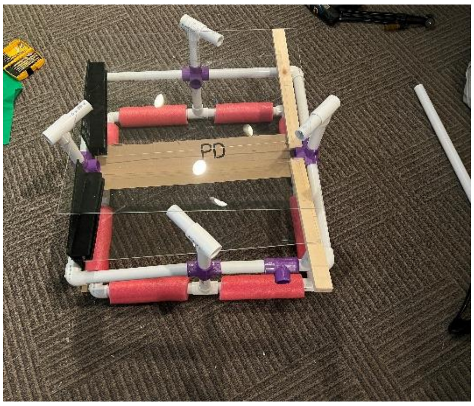
Construction and Assembly of the Core of the Design

Cutting and Fitting Foam Tubes to the Base



Installing the Second Layer and 3D Printing Plexiglass Side Plate Holders





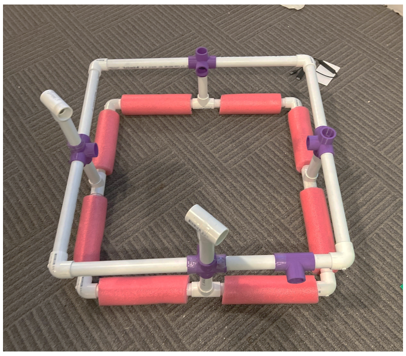
Finalizing the Prototype with Internal Water Collection Unit and Adjusting the Top Plexiglass Layer to Use Less PVC (ultimately PLA)

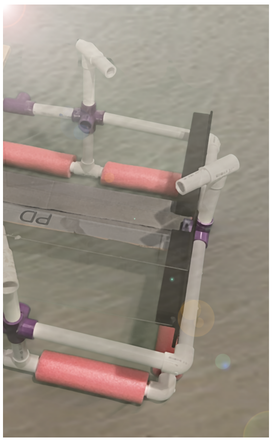
	Task	Equipment	Quality Control	Risk Assessment	Time
Materials	Order PLA Filament	Not Applicable			10 mins
	Order Plexiglass				10 mins
	Order Polyethylene				10 mins
Processing	Print all required piping (A-F, H, K)	SLA 3D Printer	Remeasure after printing and ensure accuracy within ~1in	Ensure print plate is properly adjusted.	~8 days
	Print out the foam tubing (G)	FDM 3D Printer	Remeasure after printing and ensure accuracy within ~1in	Ensure print plate is properly adjusted. Wear gloves/masks when curing.	~2 days
			Ensure flexibility by bending and viewing water buoyancy		
	Cut plexiglass to appropriate dimensions (I & J)	Band Saw	Remeasure after cutting and ensure accuracy within ~1in	Be careful with saw, wear apron, wear gloves	40 mins
	Drill required holes in plexiglass (if any) (I & J)	Drill Saw	Use size-accurate screws to ensure hole accuracy	Be careful with saw, wear apron, wear gloves	30 mins
Assembly	Seal the plexiglass panels to their appropriate fixings (top or Plate Holder [H])	Adhesive	Ensure the strength of these connections through applying force as well as thorough application of adhesive	Be careful with adhesive, wear apron, wear gloves, wear mask	1-2 hrs
	Cut and seal foam tubing to the bottom A piping.	Blades & Adhesive	Ensure foam tubing is sealed	Be careful with adhesive, wear apron, wear gloves, wear mask	30 mins
			Test for buoyancy before and after application		
	Connect piping together in its intended structure	Hammer / Clamps	Use clamps/hammer for force to ensure tight fit / no leakage	Ensure fingers are out of way of hammer	40 mins
	Apply a sealing primer to the piping and holes between components to prevent water damage	Sealing primer	Place product (or run water along specific pipes) in water to identify possible leaks	Be careful with primer, wear apron, wear gloves, wear mask	30 mins
Finishing	Wear down the rough edges of the product that may make the transportation experience unpleasant	File / Sandpaper	Make sure to file/sand any areas of slight roughness.	Ensure fingers are out of way of sandpaper and ensure filing doesn't damage functionality	10 mins
			Proficiently check for rough edges by running sandpaper along the sides		
	Recolor the product (if necessary) to match the surrounding environment of its implementation	Spray Paint	Ensure edges, plexiglass, and other unintended-for-paint materials are covered. Apply multiple (at least 3) layers	Be careful with primer, wear apron, wear gloves, wear mask	1 hr (total)
	Clean and secure (fill empty space) the top and evaporation panels to prepare for shipping	Window Cleanser & Packing Foam	Apply necessary cleansing to each panel.	Be careful and thorough with cleanser	10 mins
			Check light intensity (transparency) with a lux meter		

Testing Strategy & Justification:

Justification: To fully test the product, user testing is needed as testing with the client to see if they see a significant improvement when using the system.

Steps:	Testing Strategy Description:
1	Conduct laboratory testing to determine the efficiency and effectiveness of the distillation process under controlled conditions.
2	Test the durability and longevity of the product by simulating long-term use (14 days) and exposure to various environmental factors. In this case, it will be tested at the Mamorneck River against the environment.
3	Test the product's ability to purify water from different sources (e.g., river, lake, ocean) and under different conditions (e.g., high flow, low flow, rainy season, dry season).
4	Evaluate the product's ease of use and maintenance requirements.
5	Assess the product's overall cost-effectiveness and scalability.
6	Conduct a market comparison to see where the system fits in the market compared to existing products.
7	Test the product's compliance with relevant standards and regulations.
8	Conduct a pilot test with a small focus group of targeted customers (Generational: aged 7-12; aged 18-25; aged 35-50) and collect feedback from users and incorporate it into the product design/development process.





Evaluation Against Design Specifications:

Specification:	The prototype should've…	Eval.	Why?
Target Market	*From the focus and performance group…*		
	Be designed for use outside of the home and in robust environments	PASS	Product survived a multitude (rain, snow, shine, etc.) of weather conditions.
	Be designed for use by all age groups and take into safety considerations	FAIL	Focus group members aged 7-12 didn't understand, at first, how to collect water from the product and

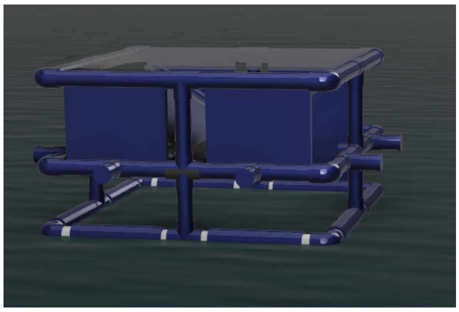
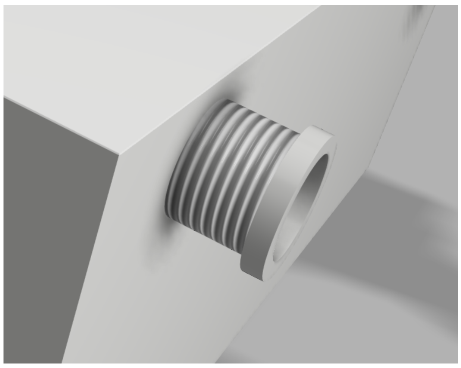
	required of use around small children (age 3-8)		often found challenges in swimming to the product to access its function
Target Audience	*From the focus and performance group…*		
	Be designed for affording use by the majority of the world's population, especially focusing on underdeveloped, perhaps uneducated, communities	PASS	This model passes the mobility test by falling within the 5th percentile wingspan (covers the 5th-95th percentile for adults 18-60 transportation). Arm length 5th-95th percentile— 40cm to 55cm. Focus group stated they "well understood" the product given only its purpose/function.
	Provide functionality without language barriers; provide obvious visual indicators for function	PASS	No language used in the setup. Focus group members aged 18-30,35-50 found its setup "natural" and has high visual affordance.
User Requirements	*From the focus and performance group…*		
	Utilize common dispense methods for water expulsion and collection.	PASS	Focus group members of all age distinctions found the tap-water system of dispensation a "like home" affordance.
	Be consistent in function and provide longevity without the need for maintenance.	PARTIAL	The product didn't require functional maintenance in its 14-day testing period (could be expanded upon).
Market Requirements & Competition	*From performance testing…*		
	Be inclusive in functionality to incorporate all users	PASS	This model passes the mobility test by falling within the 5th percentile wingspan (covers the 5th-95th percentile for adults 18-60 transportation). Arm length 5th-95th percentile— 40cm to 55cm.
	Provide competitive aesthetic and functional efficiency.	PASS	Focus group members aged 18-30,35-50 found it easy to move, setup, and retrieve clean water from the product
Functional Requirements	*From in-field testing in the Mamaroneck River…*		
	Provide WQS satisfactory drinking water at a sustainable and substantial	PASS	~4.12 gal on average across 14 test days.

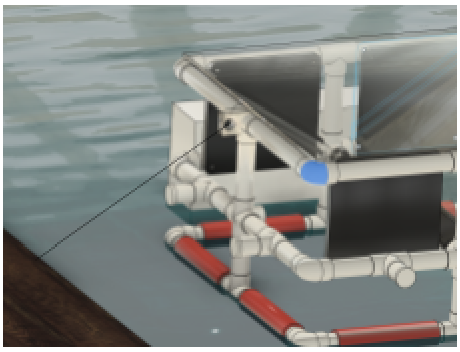
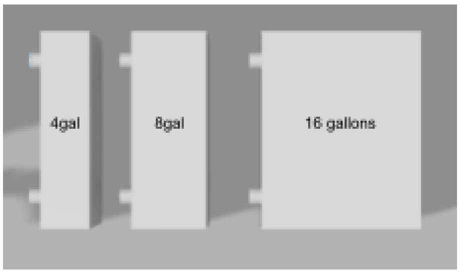
	rate (1 gallon per day per person up to 4).		
	Provide ample dirty (or input) water storage (up to 8 gallons each of dirty and cleansed-output water)	PARTIAL	With the additional storage extension, the system can hold up to 4 gallons.
Aesthetic Requirements	*From in-field testing in the Mamaroneck River…*		
	Be designed to blend into the natural environment: use green, brown, and black palettes.	FAIL	The red and white design fails to blend into the blue and green natural environments of its target market.
	Maintain a consistent profile amongst other daily applications	PASS	The design affords its use in water distillation and cleansing amongst other PVC piping utilities.
Material Requirements	Be lightweight for after-purchase transportation.	PASS	The product's weight falls within 32-35lbs (predicted 32.49 lbs in CAD model)
	Be environmentally sustainable/durable and safe for daily human interaction	PASS	PLA/Polyethylene is biodegradable. Plexiglass is recyclable.
	Be able to endure internal water strain without need for material replacement or repair	PASS	PLA plastic, the product's infrastructure, does not absorb water.
Size Constraints	Be mobile in its user carry capacity (20lbs - 40lbs	PASS	The product's weight falls within 32-35lbs (predicted 32.49 lbs in CAD model)
	Must consider the height of an adult human for water dispensation (average 5'5)	PASS	The prototype is ~2ft tall.
Cost Constraints	Cost less than $150, given modern manufacturing, to produce and should sell for under $250.	PASS	The combined cost of all parts/assembly is ~$112. This could be reduced to <$100 with mass manufacturing discounts applied.
	Cost less than $200 to produce a sustainable, as well as functional, prototype	PASS	
Manufacturing Requirements	Be designed for mass manufacturing and incorporate standardized techniques/equipment/part	PASS	The prototype was constructed from materials (PLA, Poly, etc.) that have readily available mass manufacturing processes.

	s to increase the ease of production		

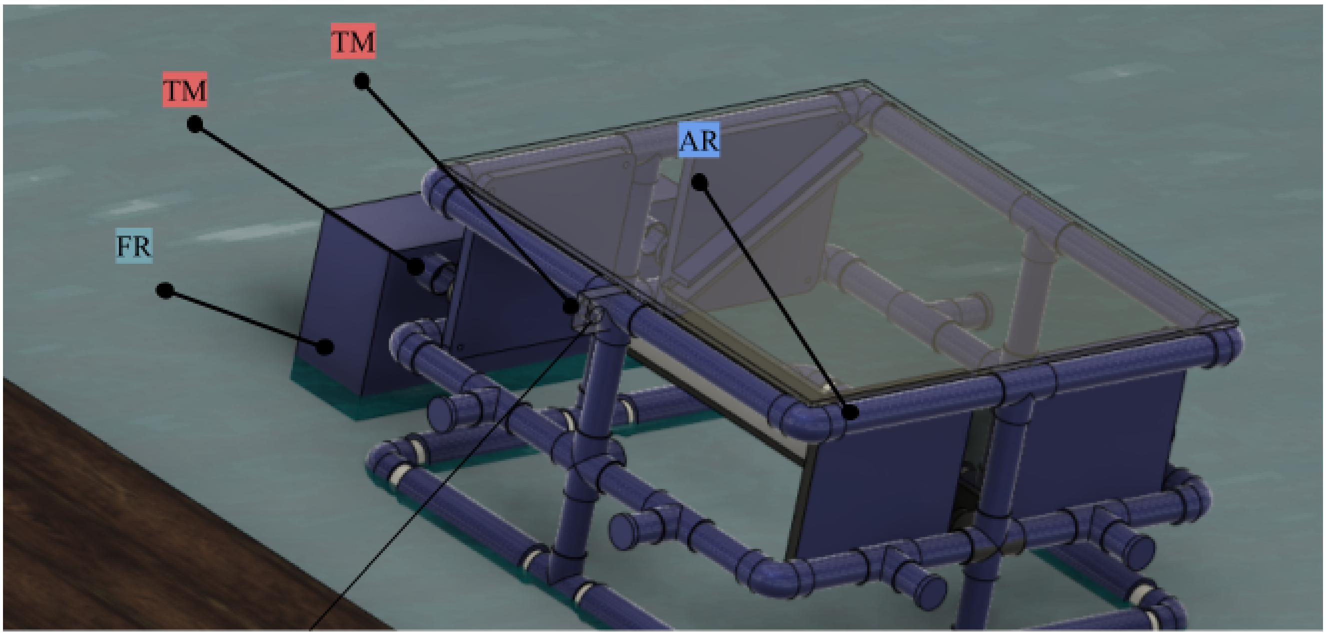
Possible Improvements:

Specification Key:			
TM TA UR MRC FR	Target Market Target Audience User Requirements Market Requirements & Competition Functional Requirements	AR MR SC CC M	Aesthetic Requirements Material Requirements Size Constraints Cost Constraints Manufacturing Requirements

Spec.	Improvement:	Benefits/Desc:	Graphic:
AR	Change the product's color to blend in better with the environment.	1. Less noticeable and less obtrusive in the natural setting. 2. Blending in with the environment can also help the product to be less disruptive to the natural ecosystem. 3. More appealing to the users 4. Minimize the impact of the product on the study area and increase the accuracy of the results (in testing).	
TM	Add safety locks to allow younger focus groups to afford the use of the product (claiming clean water from dirty water)	1. Allows for easier access to clean water for younger users through greater affordance of how to unscrew the water expansion units. 2. Decreases lingering confusion amongst other age groups that weren't captured within this limited focus group study.	

TM	Add a latch and rope to the product to keep it in shallow water for the safety of the product and younger users	1. Safer for the product itself as well as for younger users. 2. The latch and rope can also be used to secure the product to a stationary object. 3. The rope can be used to anchor the product. 4. The rope can also be used to pull the product from the water and onto the shore or into a boat or other watercraft.	
FR	Offers different sizes for water storage extensions.	1. Flexibility in terms of the amount of water that can be stored. 2. Allow users to scale the product to the size of their operation. 3. Enables the product to be used in a variety of settings, such as for camping, backpacking, boating, or longer research expeditions. 4. Can also help users to optimize the space and weight of the product 5. Increase the product's overall value to the customer and non-profit/global corporations	 4 gallons = 4 people (standard family per day) 8 gallons = 4 people, 2 days (or 8 people) 16 gallons = 4 people, 4 days (or 16 people)

Combined Improvements:

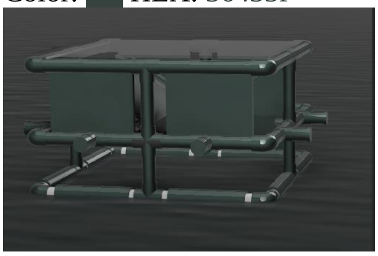
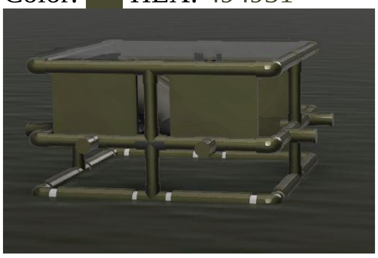


1. Color Testing

Most Common Environmental Accomediations

[1]From left to right top; Central Atlantic, Central North Sea, Coastal North Sea. From left to right bottom; Coastal North Sea during algal bloom, Wadden Sea with lots of re- suspension of sediment and a coastal outlet dominated by yellow substance.

Corresponding Brands of Product Skins for Different Suggested Environments

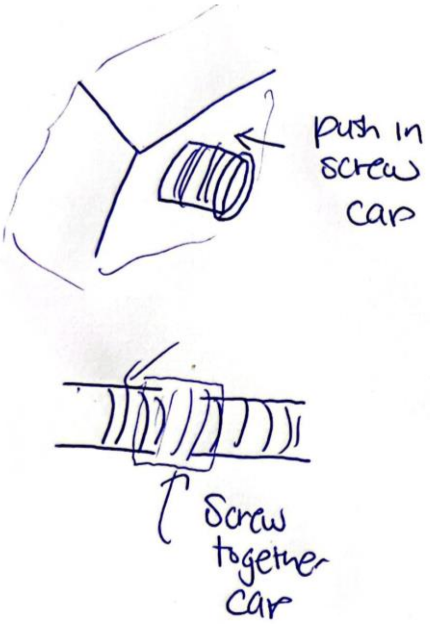
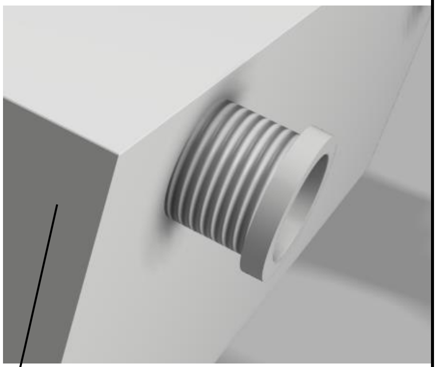
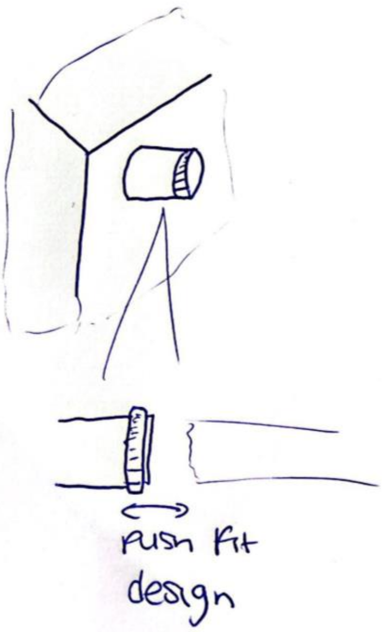
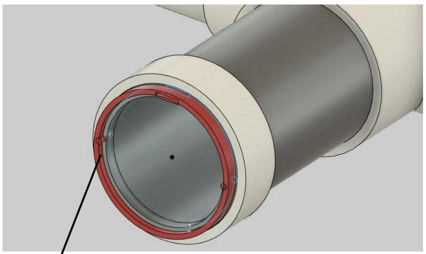
Color: HEX: 232755 	Color: HEX: 224154 	Color: HEX: 36433f 
Color: HEX: 31493a 	Color: HEX: 583f21 	Color: HEX: 494931 

Aesthetic Requirements

- ✓ Less noticeable and less obtrusive in the natural setting.
- ✓ Blending in with the environment can also help the product to be less disruptive to the natural ecosystem.
- ✓ More appealing to the users
- ✓ Minimize the impact of the product on the study area and increase the accuracy of the results (in testing).

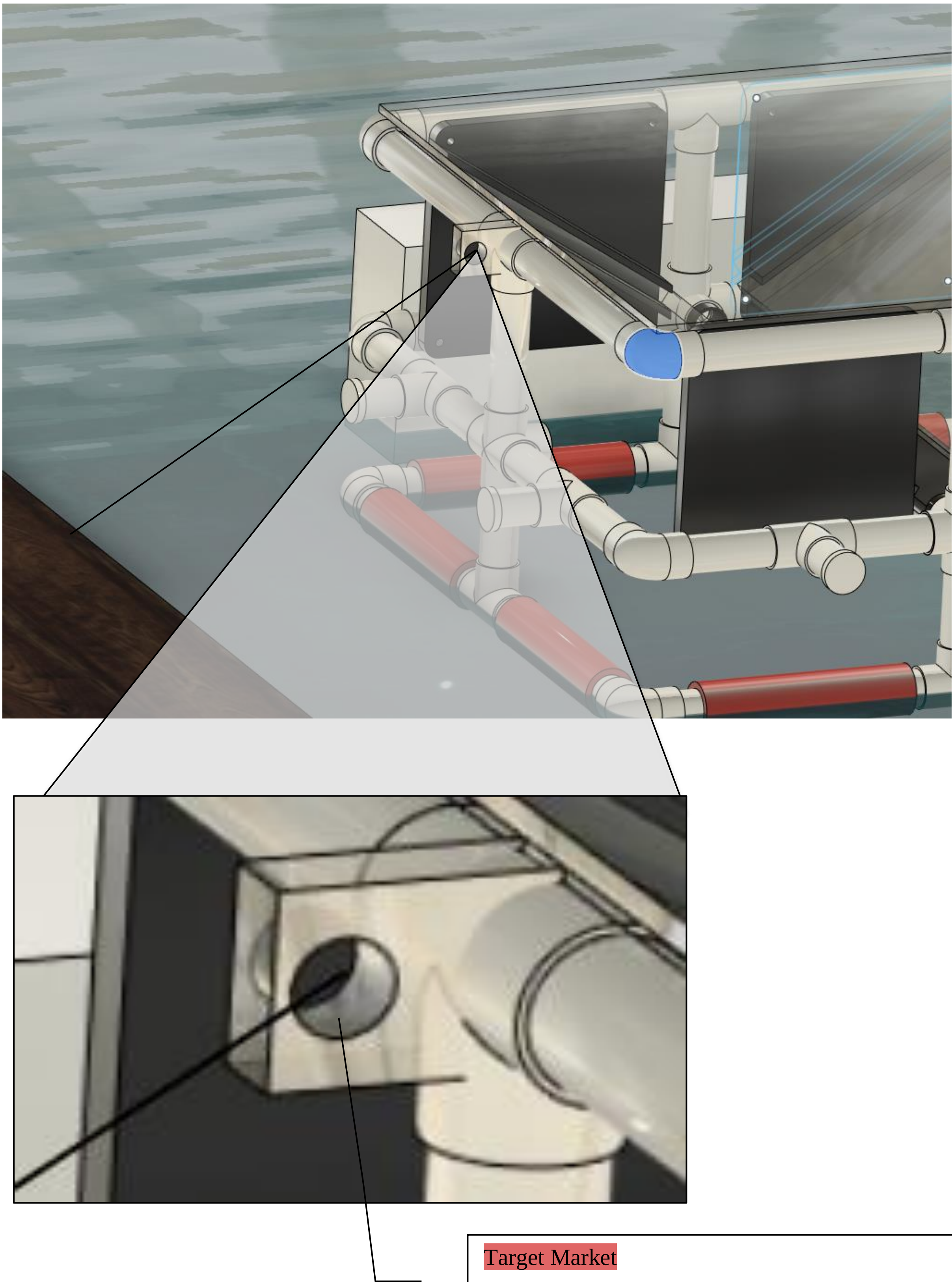
[1] “What Is Water Colour? - Citclops.” n.d. Www.citclops.eu. Accessed February 13, 2023. http://www.citclops.eu/water-colour/what-is-water-colour.

2. Safety Locks

Iteration	Sketches	Final Model
Screw cap connection between the water storage and the main product.		 Creates greater confusion/complication by affording excessive motion, especially with younger users.
(CHOSEN) Traditional push-fit design for easy attachment/detachment		 Decreases lingering confusion amongst other age groups that weren't captured within this limited focus group study. Easy push-fit

Product Decision: To keep production costs down and adapt to the largest amount of 2" PVC system in application, the storage containers themselves will not be included in the manufacturing design.

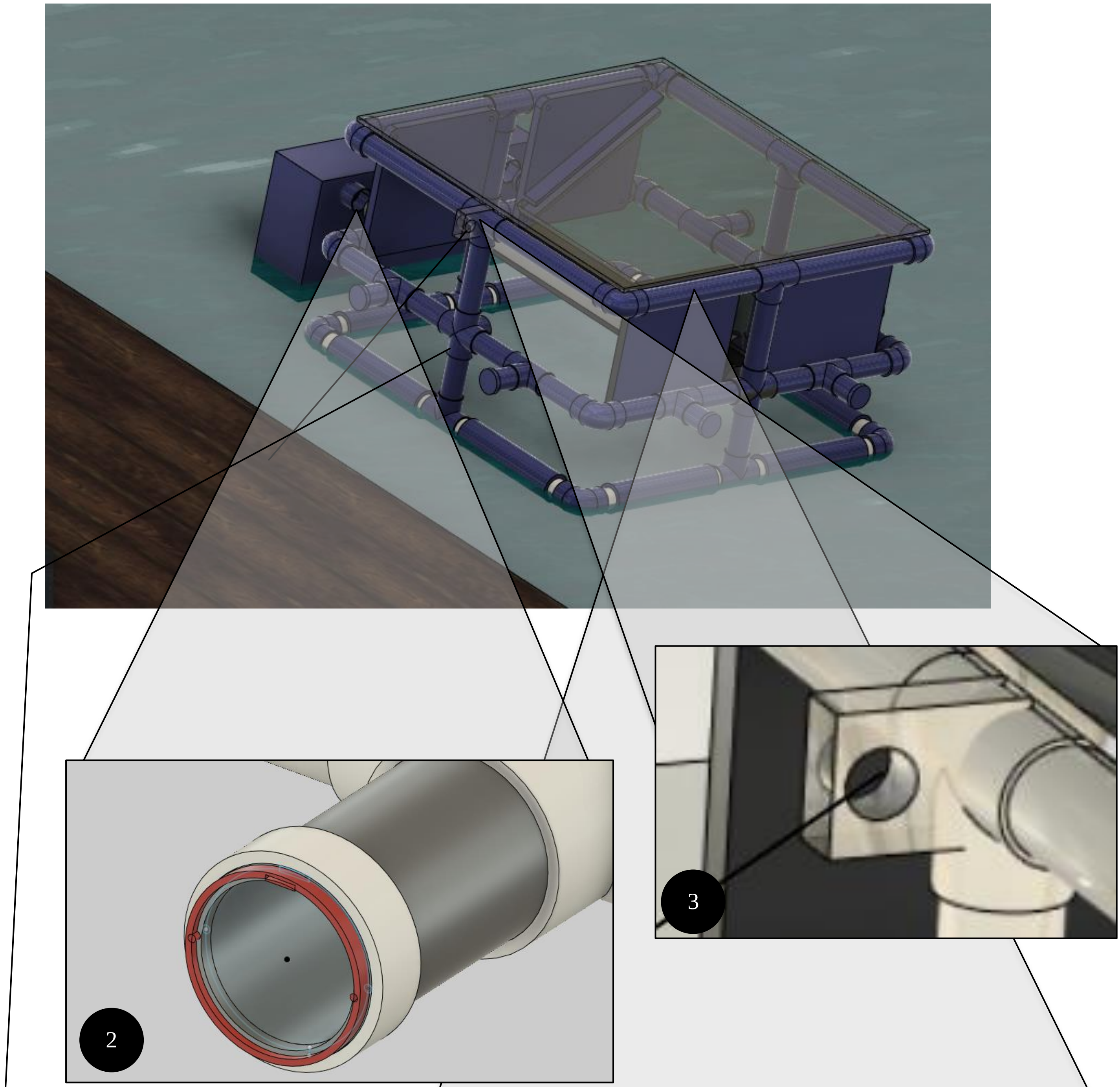
3. Grounding Latch

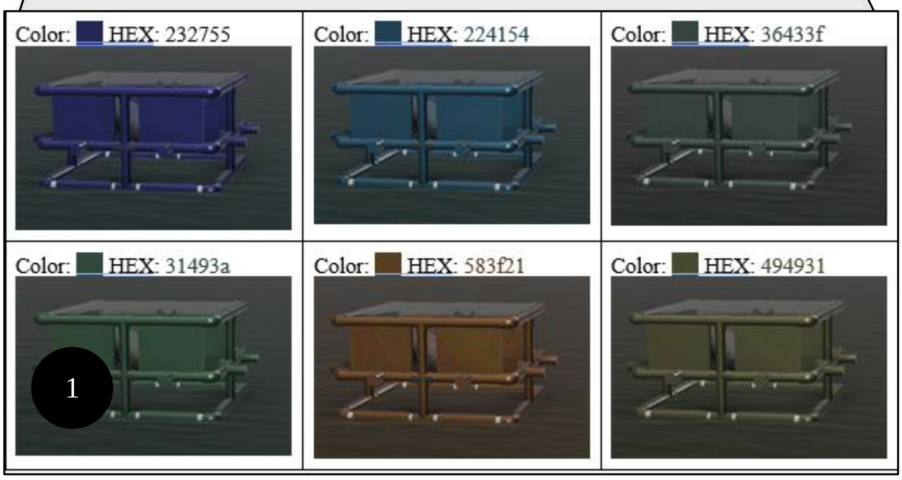


Target Market

- ✓ Allows for easier access to clean water for younger users through greater affordance of how to unscrew the water expansion units.
- ✓ Decreases lingering confusion amongst other age groups that weren't captured within this limited focus group study.

Developed Commercial Design





Key Checkpoint:

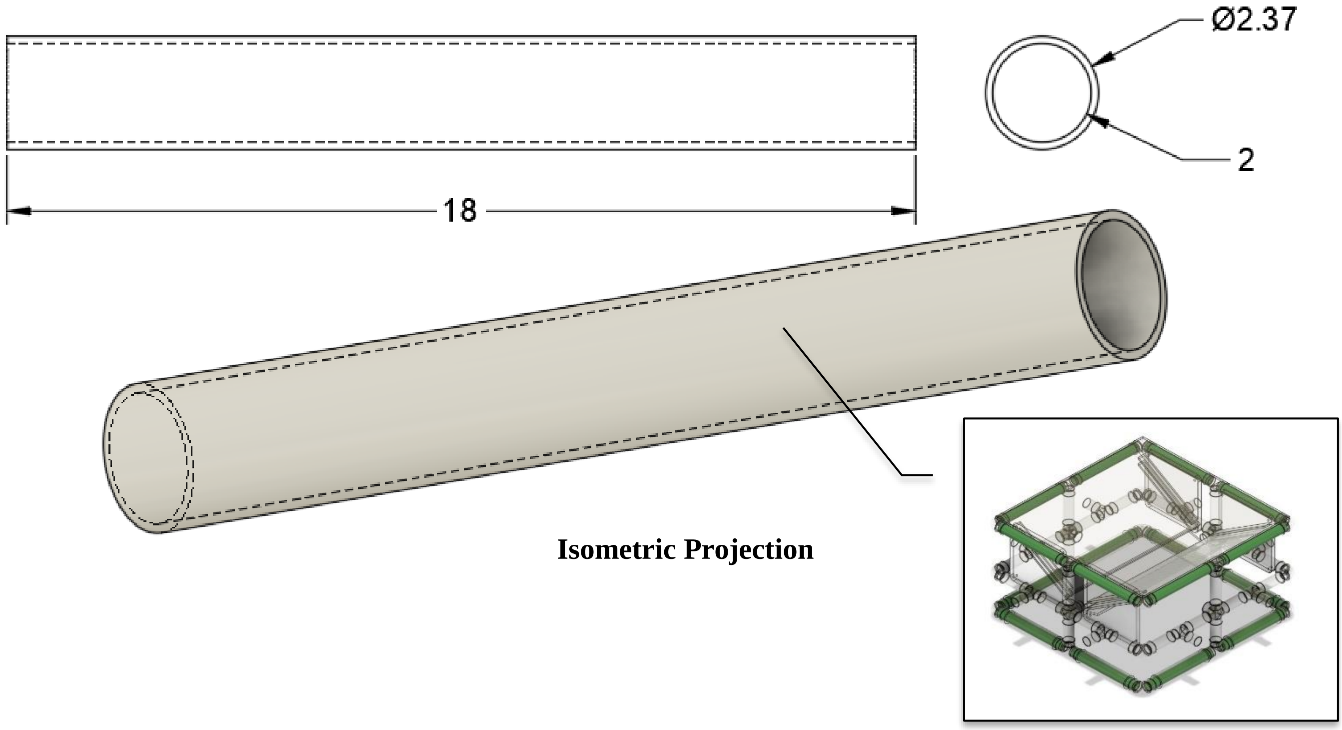
- ✓ Mobililty
- ✓ Inclusive
- ✓ Accessible
- ✓ Safe
- ✓ Marketable
- ✓ Feasible

Part		Material Volume Approx.	Material	(External - Internal) Radius	Quantity
A	18" - 2" Piping	19 in^3	PLA Plastic	0.37"	16
B	9" - 2" Piping	10.9 in^3	PLA Plastic	0.37"	8
C	6" - 2" Piping	8.4 in^3	PLA Plastic	0.37"	16
D	R-Tee 2" Piping	14.45 in^3	PLA Plastic	0.37"	16
E	Elbow 2" Piping	12.4 in^3	PLA Plastic	0.37"	12
F	3-Axis 2" Piping	18 in^3	PLA Plastic	0.37"	4
G	14" - 2.4" Foam Tubing	20 in^3	Polyethylene	0.82"	8
H	Plate Holder	261.9 in^3	PLA Plastic	Not Applicable	2 (Both left and right orientation provided in each)
I	Plexiglass Plates	876.4 in^3	Plexiglass		2
J	Plexiglass Roofing	924.5 in^3	Plexiglass		1
K	Basin-2" Piping	181.9 in^3	PLA Plastic	0.37"	1

Part diagrams—All measurements in inches

Part A: 18" - 2" Piping

Orthographic Projections

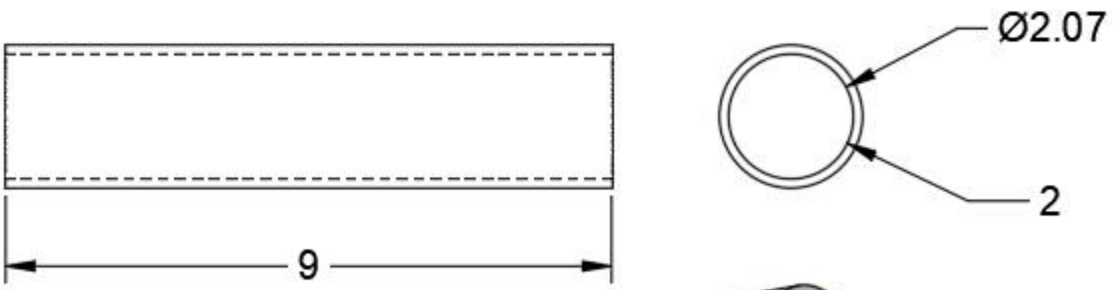


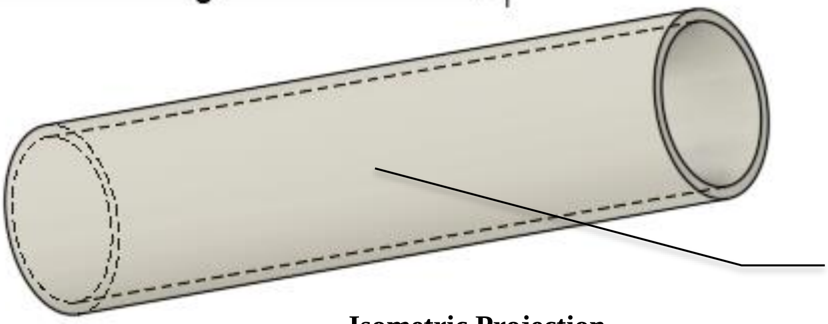
Isometric Projection

Part B: 9” - 2” Piping

Scale: 1:2

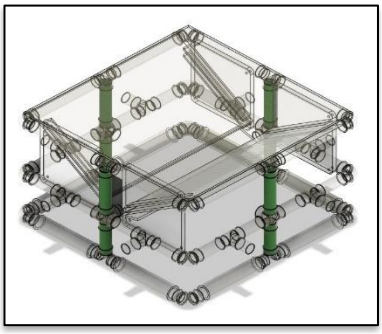
Orthographic Projections





Isometric Projection

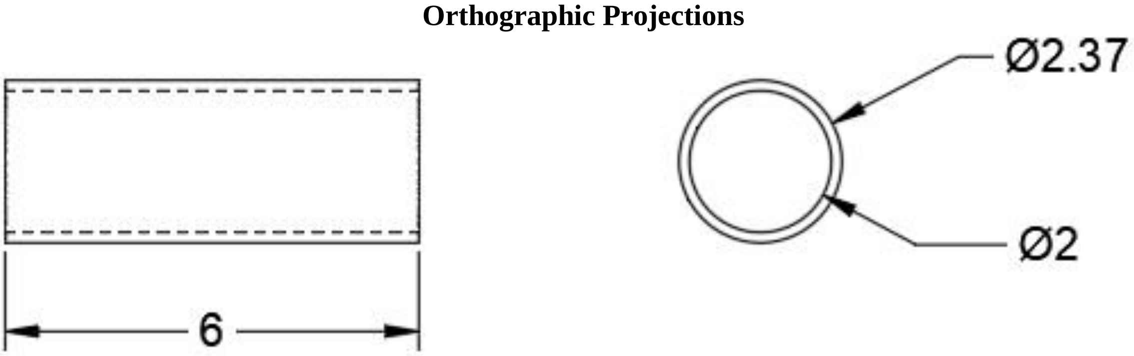
Larger Picture:

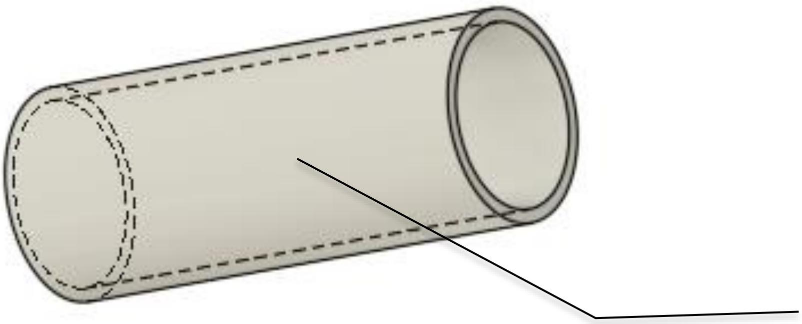


Part C: 6” - 2” Piping

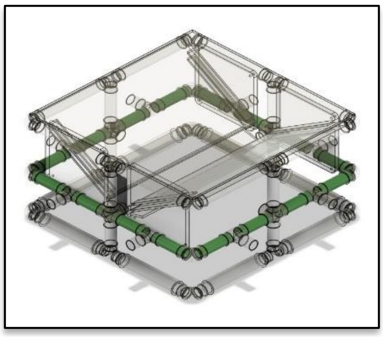
Scale: 1:2

Orthographic Projections





Isometric Projection



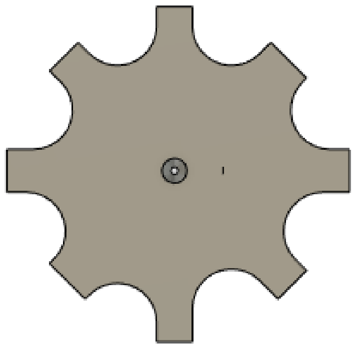
Part A, B, & C Injection Molds

Scale: 1:2

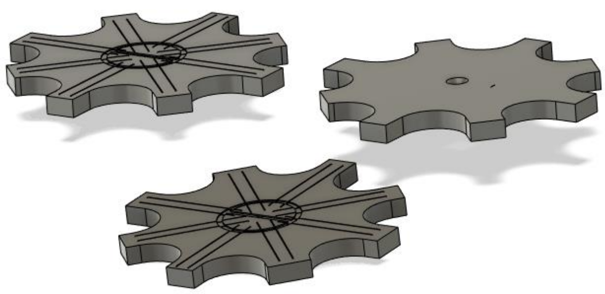
Adjust Pipe Length based upon part:

Example Mold (18”)

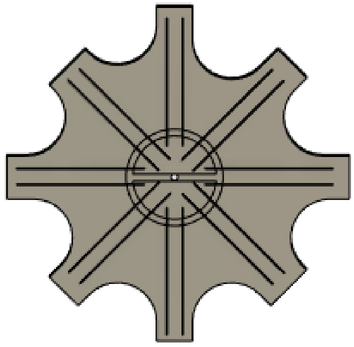
Bottom (Face Up)



Top (Outside Up)



Isometric Projection

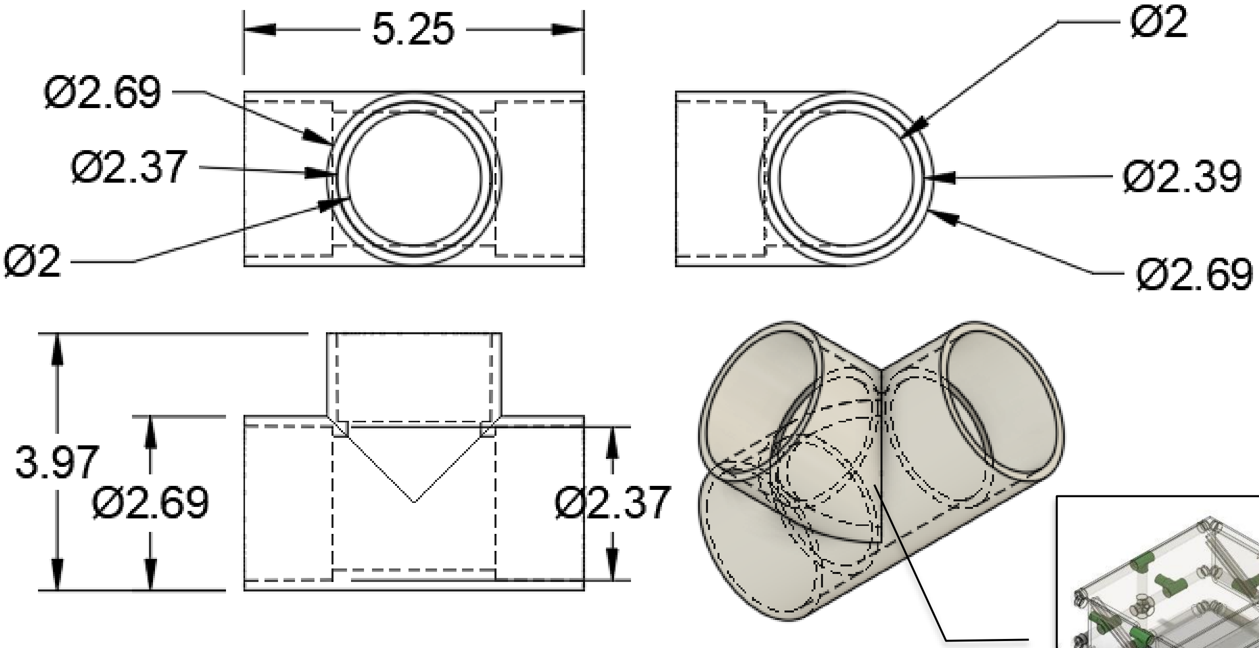


Top (Face Up)

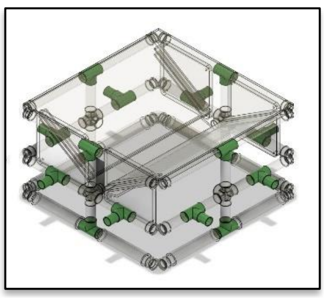
Part D: R-Tee 2” Piping

Scale: 1:2

Orthographic Projections

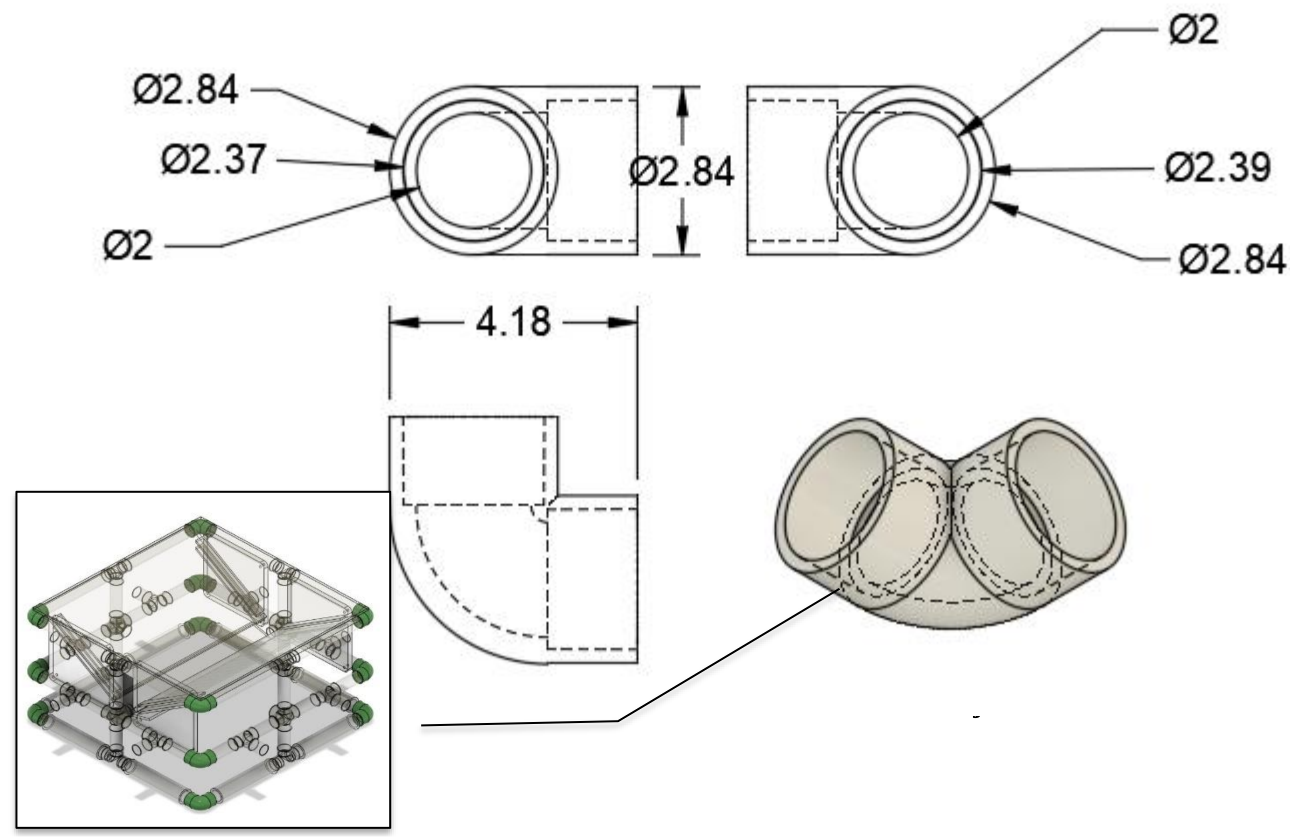


Isometric Projection



Part E: Elbow 2” Piping

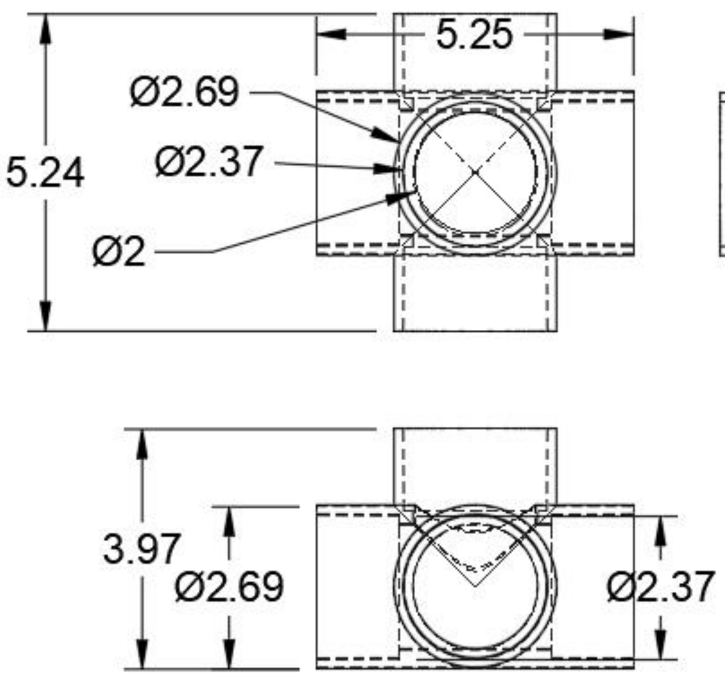
Scale: 1:2

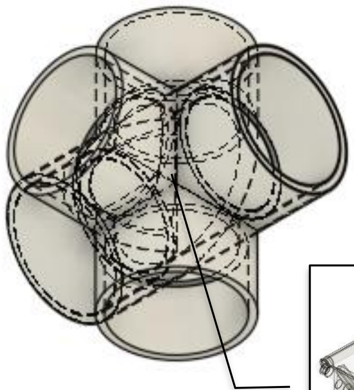


Part F: 3-Axis 2” Piping

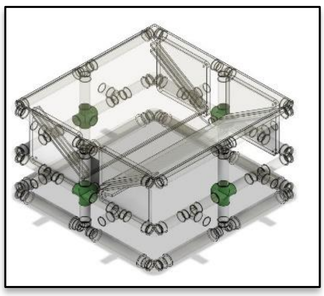
Scale: 1:2

Orthographic Projections





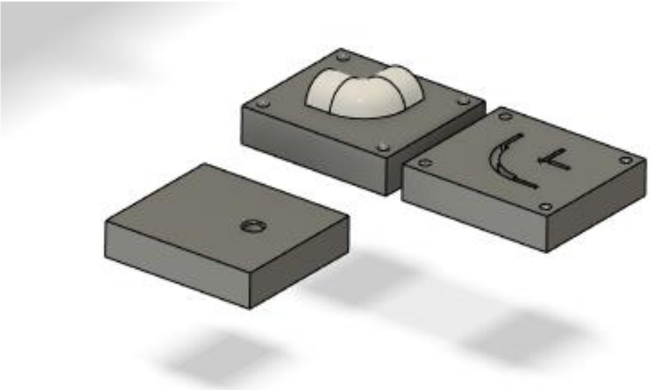
Isometric Projection



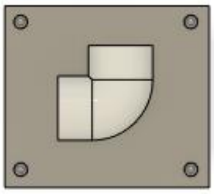
Part D, E, & F Injection Molds

Scale: 1:2

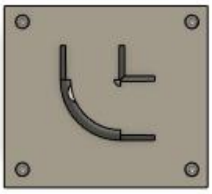
Example Mold (Elbow 2" Piping)



Isometric Projection



Top (Face Up)



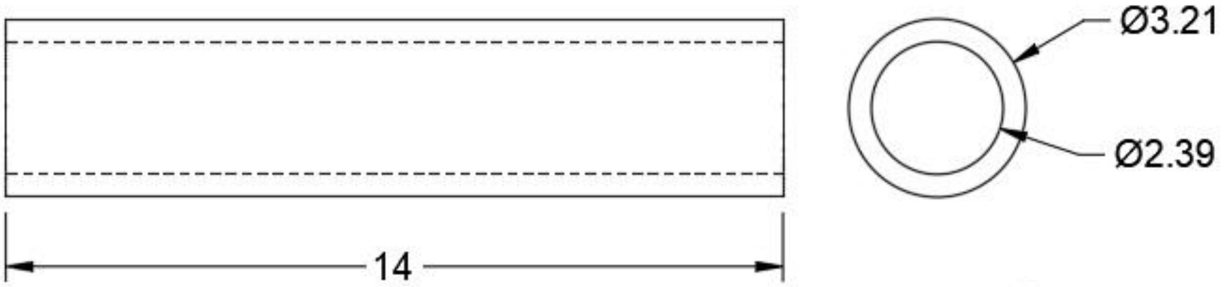
Bottom (Face Up)

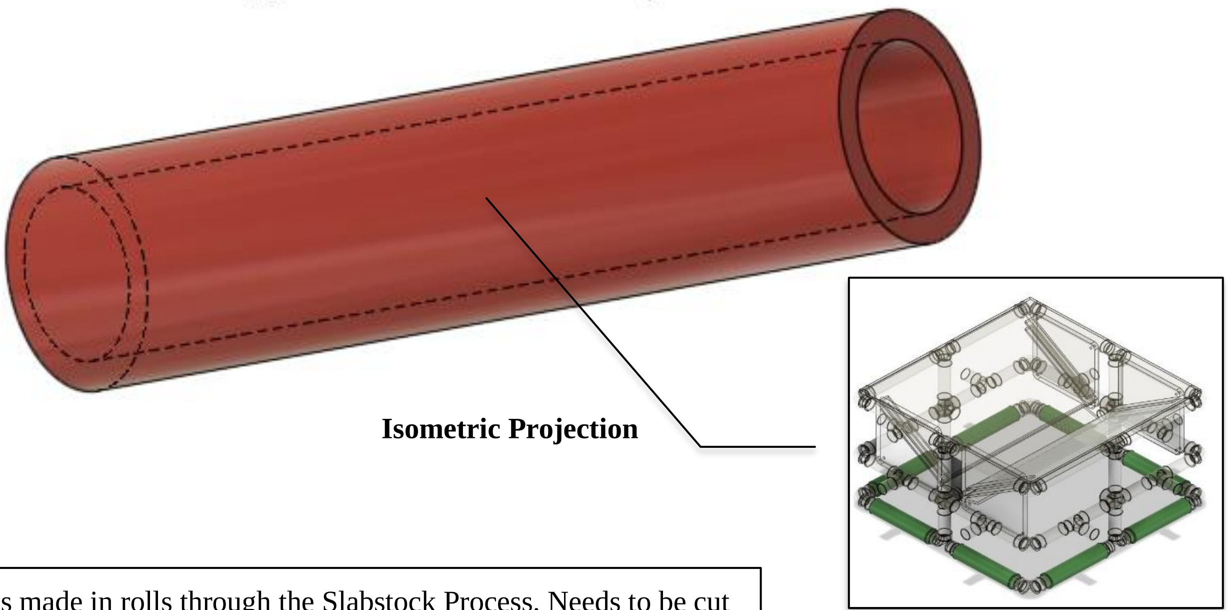
Top (Outside Up)

Scale: 1:2

Part G: 14" - 2.4" Foam Tubing

Orthographic Projections





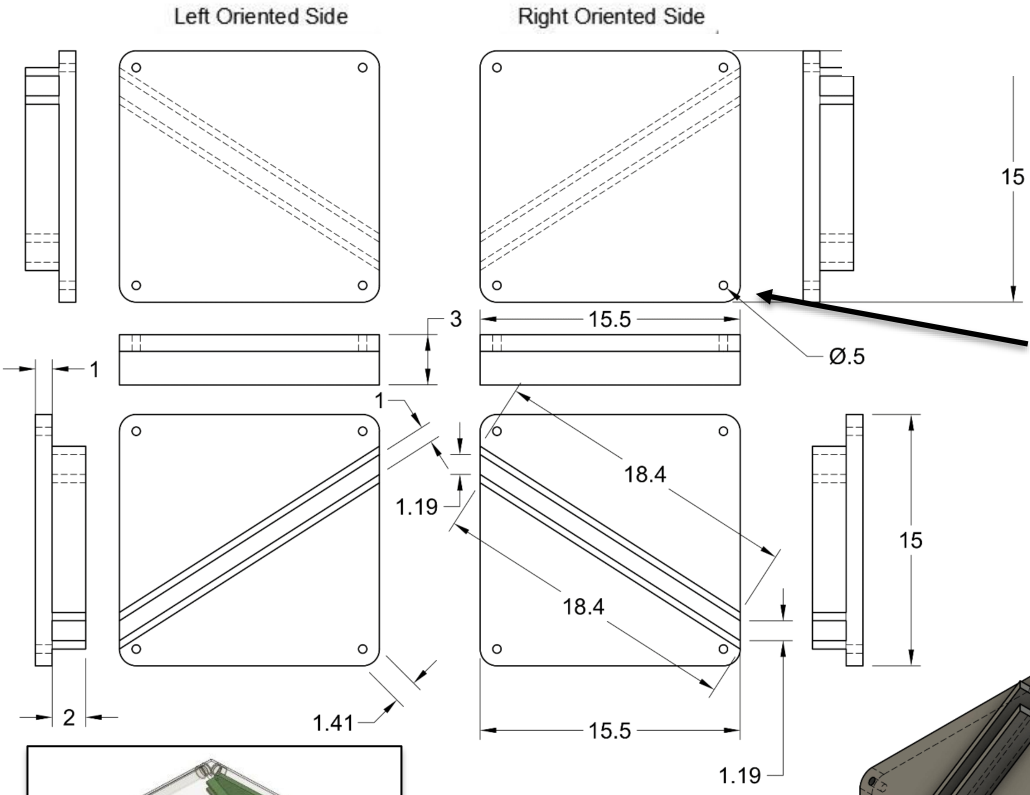
Isometric Projection

Material is made in rolls through the Slabstock Process. Needs to be cut to the size of 14". Manufacture using dimensions above.

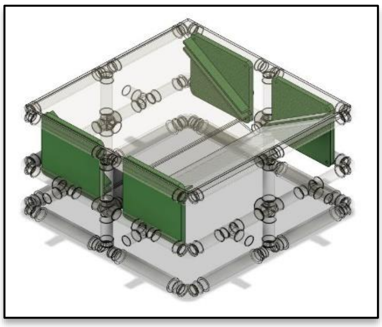
Part H: Plate Holder & Injection Molds

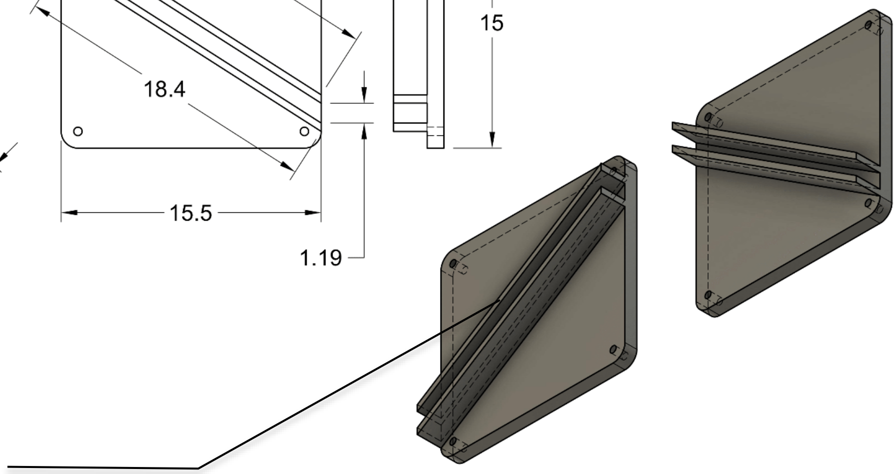
Orthographic Projections

Scale: 1:4

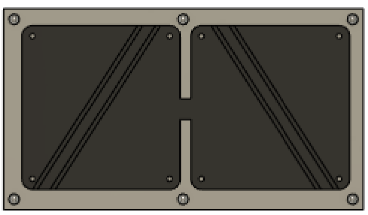


0.5” holes provided if necessary (not using adhesive)

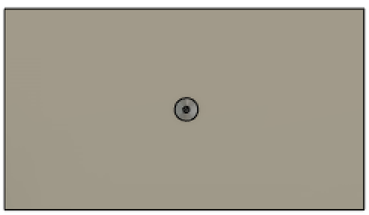




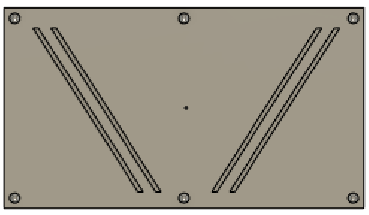
Isometric Projection



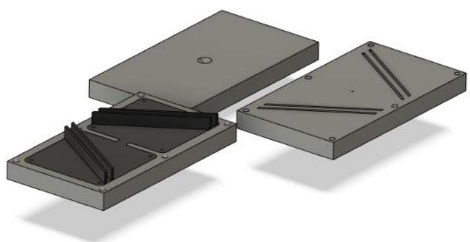
Bottom (Face Up)



Top (Outside Up)

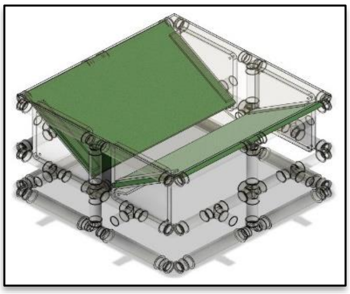


Top (Face Up)



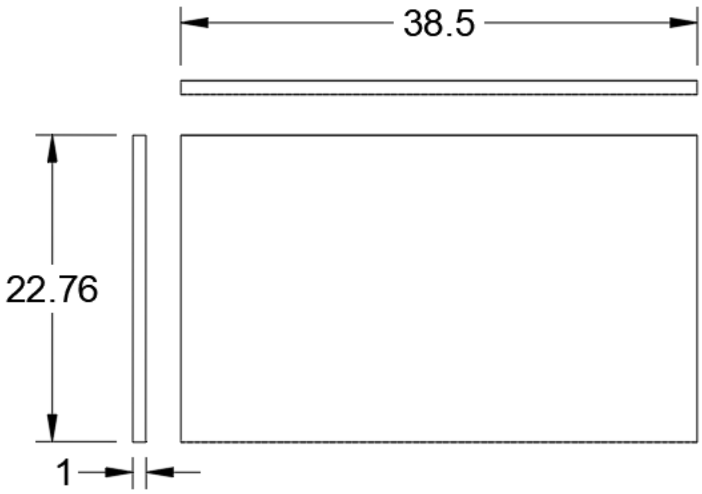
Isometric Projection

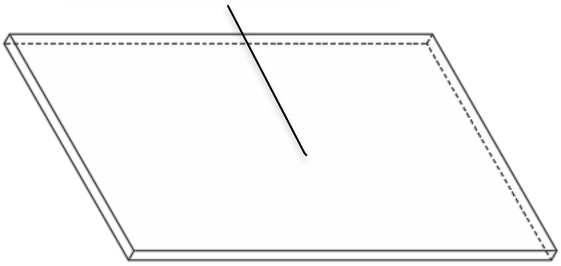
Part I: Plexiglass Plates



Scale: 1:4

Orthographic Projections





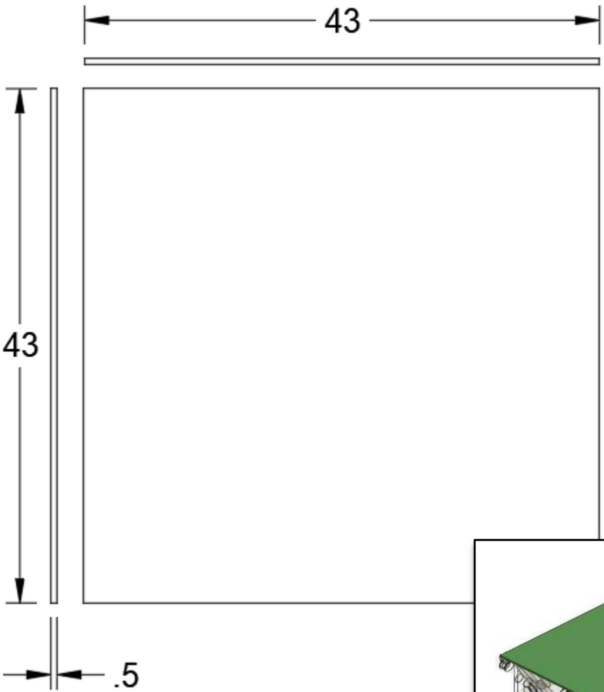
Isometric Projection

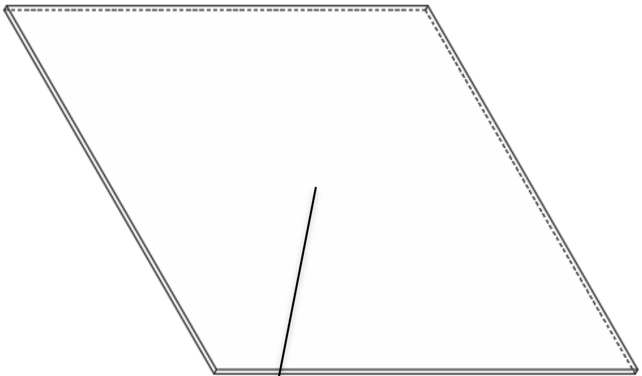
To be cut using a CNC machine and the drawing above **(in a .dxf format)**

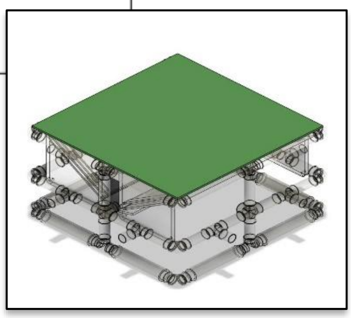
Part J: Plexiglass Roofing

Scale: 1:4

Orthographic Projections







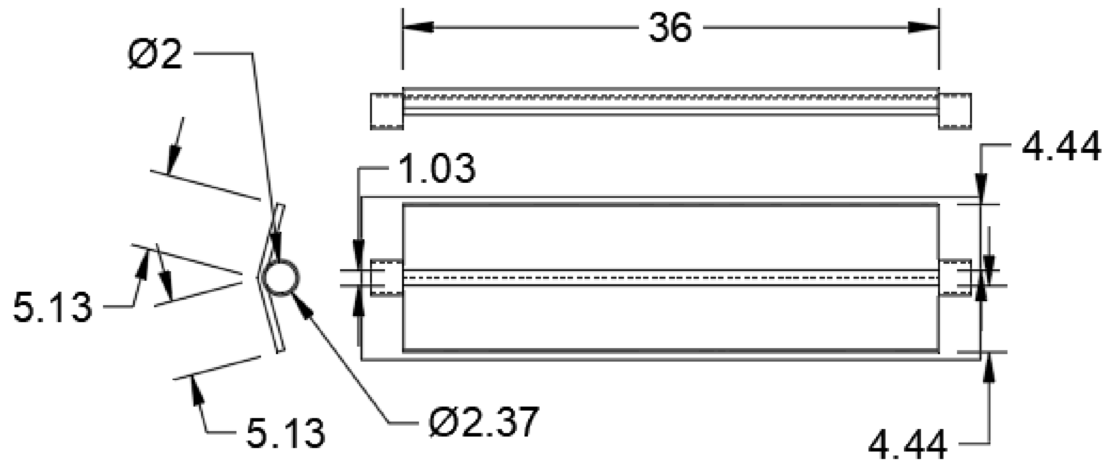
Isometric Projection

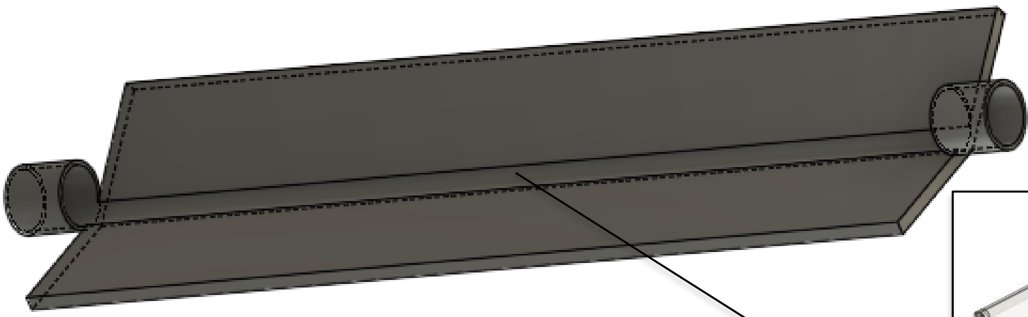
Scale: 1:2

To be cut using a CNC machine and the drawing above **(in a .dxf format)**

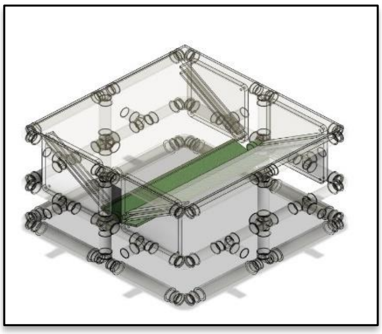
Part K: Basin-2” Piping & Injection Molds

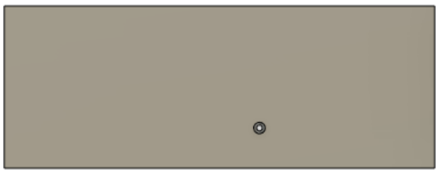
Orthographic Projections



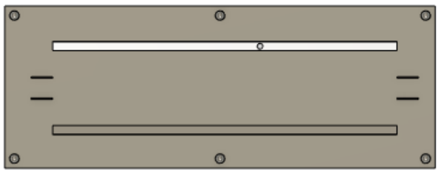


Isometric Projection

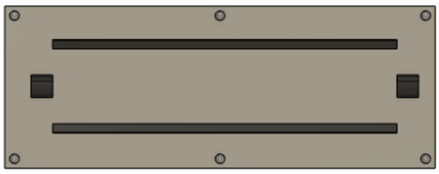




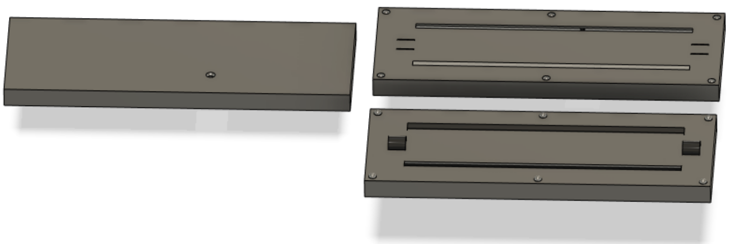
Top (Outside Up)



Top (Face Up)



Bottom (Face Up)



Isometric Projection

Justification of commercial production methods:

Instead of using the toxic Polyurethane (Rubber) used for the foam floaters on the bottom of the prototype, the commercial production will use **Polyethylene**. The Polyethylene foam bottom borders act as a function for keeping the device floating above the water. The material's high buoyancy (and high buoyancy life cycle) makes it desirable because it allows the device to remain in function, without disruption, for 10+ years while also being replaceable upon a request for maintenance. In addition, Polyethylene is highly durable and a known biodegradable material, with a life of 22-30 years, and more once protected with a different coating. This means less waste is produced. In addition, the material is completely biodegradable and recyclable towards the end of the product life cycle. All of these factors make the material more suitable for commercial production as it is ultimately recyclable towards the end of its product life cycle.

As with the prototype, **Biodegradable PLA** will be used for the piping and panel holders. The benefits of this material include its weather resistance, its lifespan of 12-18 years, and its durability as a lasting structure for the exterior of the commercial product. When manufacturing, the required PLA components can be produced using rapid injection molding as opposed to the slower 3D printing processes used to create the prototype. This material is also abundant and easily replaceable which, in turn, helps it achieve the highest cost efficiency among other materials (Carbon Fiber, Fiberglass, Kevlar composites, etc.)

Finally, the clear light-directing panels will be made out of 0.5” **Plexiglass (Methyl Methacrylate)** sheets. The transparency of the panels allows users to look through the product from the top and analyze any possible damage/capacity issues that may arise. In addition, they are easy to clean and have a lifespan of 10+ years under varying environmental conditions.

Justification of commercial production components:

The **PLA panel holders** allow for stability and 45-degree precision. In commercial production, these components insure product consistency and guaranteed functionality across all markets.

0.5” screws are beneficial in order to secure the panel holders to the pipe-based exoskeleton and the plexiglass panels tightly into the panel holders. They are also easily removable and broadly available within commercial manufacturing.

A **large water funnel cover** allows for easy drainage of water in the case of an overflow, control over the direction of clean water into the water storage system, and protection against environmental factors (like rain or floods) that could contaminate the stored clean water.

Justification of commercial production manufacturing techniques

CAD Software: The use of programs like Fusion 360, AutoCAD, and Blender (for realistic rendering with Cycles) allows for efficient production, easy metric/dimensional adjustment, and exact measurements for manufacturers to replicate. This creates an accurate transfer of ideas that is necessary for this product to succeed as a commercial product.

Waterjet CNC: The use of a two-dimensional CNC machine (like the X-Carve Pro 4x4) would be necessary for rapidly cutting assembly line plexiglass panels to accompany the three required for the commercial product. This type of machining is very appropriate for batch-scale production. Given that CNC machines are widely available and extremely precise, they would be suitable for cutting the required two panels of 22x38.5” and the overlapping panel of 43x43” in plexiglass. Cutting these three panels takes 23 minutes when using 0.5” plexiglass and such processes would be maximized in an assembly line formation with multiple machines. CNC offers consistent and studied automation crucial to large-scale commercial production.

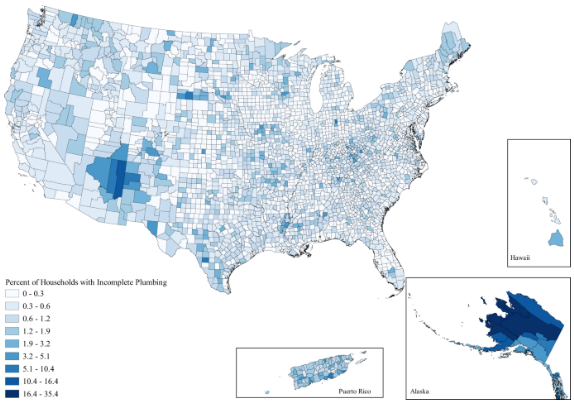
Belt Sander: A mobile belt sander would be used by a laborer as a finishing technique to quickly shave sharp edges in the plexiglass and around connected piping. This process would take around 10 minutes to complete, but would ultimately increase manufacturing and transportation efficiency within commercial production.

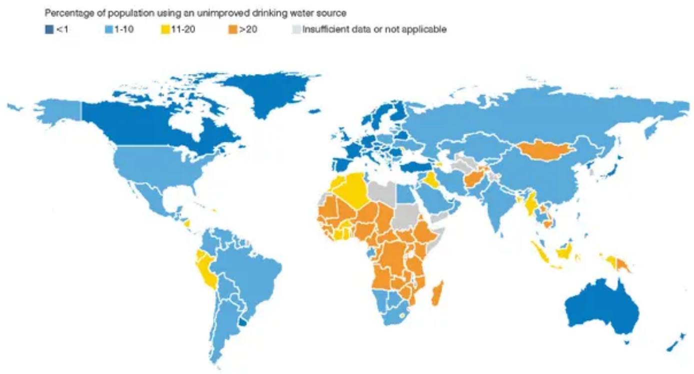
Spray Painting: As part of the finishing processes, a laborer will spray the tubing of the commercial product with a specific color to match the region it is being assigned to. Although this customization disrupts the consistency of mass production, it is a worthy trade-off in order to truly address the appearance needs of individual target markets and develop trust within the consumer base. Each piping installation will require one undercoat, one paint coat, and one water-proof varnish. Each of these coats will take around 10 minutes to apply and the process, excluding wasted time, will take around 35 minutes for each product.

Foat Fitting and Packaging: At the final stage of manufacturing, each product will be fitted and packaged in foam exteriors to avoid unnecessary damage during transportation. Outsourcing the production of polyurethane foam protective packaging, each product will take 5-10 minutes to wrap. The protective layering will include one block of protective interior foam, two mold-like foam halves to box in the exterior of the product, and additional bubble wrap to fill in any missing gaps. Such protection will be lightweight and included in the packaging pricing within the budget.

Scale and volume of commercial production

The scale of the water purification market are vast from the isolated rural areas of many western nations to the remote undeveloped communities in Sub-Saharan Africa. While the market value of water purifiers as a whole is $30.62B as of 2022, most of this product's target market will be first-time users in critical areas.[1] These "Launch Markets" are based upon a ramp-up of product production from a domestic/local scale to, eventually, the global impact outlined in Criteria A. In some markets where direct-to-consumer selling isn't feasible, such as specific territories of the DRC, partnerships with local governments and NGO's are necessary. As opposed to commercial selling where the units sold come from population estimations, regional partnerships will rely upon the partner's self-described buying power when it comes to production units. Success in each preceding market will determine the launch into the next domestic/global market.





Launch Market	Period of testing before next phase of launch	Total percent of people without access to clean water - March 2023		Total units projected as of - March 2023 (**A2E** = According to Expert)	
		Low Range	High Range	Low Range	High range
Coconino County, AZ	2-3 months (Improve Flagstaff Now Foundation)	5.1%	9%	15 A2E	25 A2E
Central Valley, CA	8-12 months (Commericial Advertisement)	5.1%	9%	35 **Estimation:** Percentage X Land per 10 miles2	80 **Estimation:** Percentage X Land per 10 miles2
Southern U.S.	10-12 months (Commericial Advertisement[2])	2.3%	3%	400 **Estimation:** Percentage X Land per 10 miles2	450 **Estimation:** Percentage X Land per 10 miles2

[1] Water Purifier Market Size, Share, Trends | Global Industry Report, 2027. (n.d.). Www.fortunebusinessinsights.com. https://www.fortunebusinessinsights.com/water-purifier-market-103118

Accra, Ghana	2-3 months (Partnered with Afri-Alliance for expert advise)	20%	30	40 A2E	50 A2E
Central Africa	10-12 months (Partnered with Afri-Alliance for expert advise)	20%	30%	350 A2E	400 A2E
Sub-Saharan Africa	12-18 months (Partnered with Afri-Alliance for expert advise)	20%	30%	850 A2E	900 A2E
Southeast Asia	12-18 months (Partnered with Asian Development Bank for expert advise)	15%	30%	320 A2E	350 A2E

Fixed costs (Source: Expert interviews, secondary research)	**Variable costs (Source: Expert interviews, secondary research)**
Waterjet CNC machine (2): $8,000	Materials per Unit: $80
Tube and foam molds: $12,000	Labour (Average labor wage $15/hour): $60
Machinery maintenance: $800	Shipping: $15
Other equipment & Utilities (CAD software subscription, Belt sander): $800	Packaging: ~$23.00 (Foam covering and boxing)
Total fixed costs: $21,600	Total variable costs: $178

Following a competitor analysis and various expert appraisals, the unit price of the product will be $260, positioning it as both an eco-friendly consumer product and a sustainable solution for NGOs.

At this market price, the production will break even at **255 units sold**. Therefore, given the data from the product's estimated roll-out, it will likely break even as sales progress through the Southern United States market which will allow profit to go back into marketing, further life cycle analysis, and productional efficiency.