# **Challenges Abroad:** Rainwater Harvesting System

# Outline

- Overview of the Problem
- Elements of the Problem
- Proposal of Rainwater System
- Conceptual Sketch
- Rainwater Collection
- Preliminary Filtering
- First Flush Diverter
- Rainwater Storage Options
- Filtering Options
- Secondary Tank & Tap
- Maintenance of System
- Testing of Available Water
- Estimations of Costing
- Limitations of Design
- Sources of Inaccuracy
- Opportunities for Further Research
- Where To From Here?

# Overview

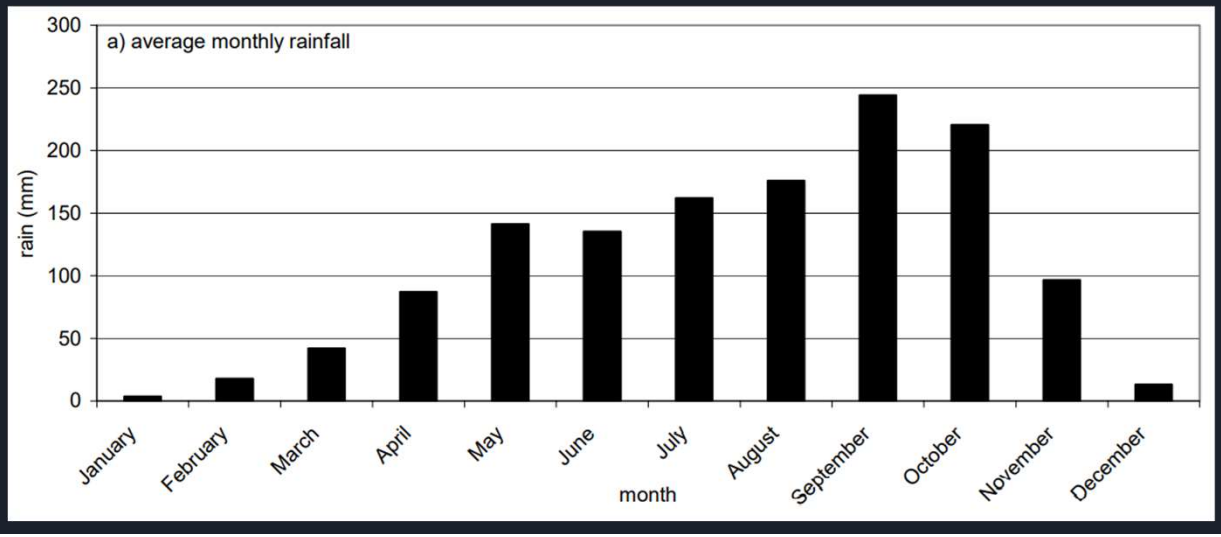
The Supplementary Education Center (SEC), funded by Future Sense Foundation (FSF), requires a long term solution for their drinking water and hygiene water for their 500 students, 20 staff & 20 temporary volunteers. SEC runs on a half day schedule and plans to expand in the near future so this solution would have to provide for over 250 children and 20-30 adults at any one time.

| Key Problems | Currently |
| --- | --- |
| Received unfiltered water from the government | Drinking water is supplied from 20L bottles |
| Government water is subjected to 3 shut off periods, contract will be reevaluated within the decade | Current statistics claim that 120L is consumed per day for drinking. Hygiene amount is uncertain |

Note: there is doubt towards figures, estimating water consumption carries uncertainty as varies with seasons, individual age and activity level

# Elements of the problem

SEC (13.162959, 103.190102), run by CAD, requires a long term solution for both their drinking water and hygiene water. Water is provided by the government and mobile carts, funded by FSF. This is not economically or environmentally sustainable. They are subject to dry periods and this is unfiltered water. Water is in high demand in the dry season between December and April, and if water is provided by the school more children are able to come to school and be healthy.  A solution for this project comes under SDG 6 (Water & Sanitation) while encouraging attendance at a Supplementary Education Center, fulfilling SDG 4 (Access to Education)

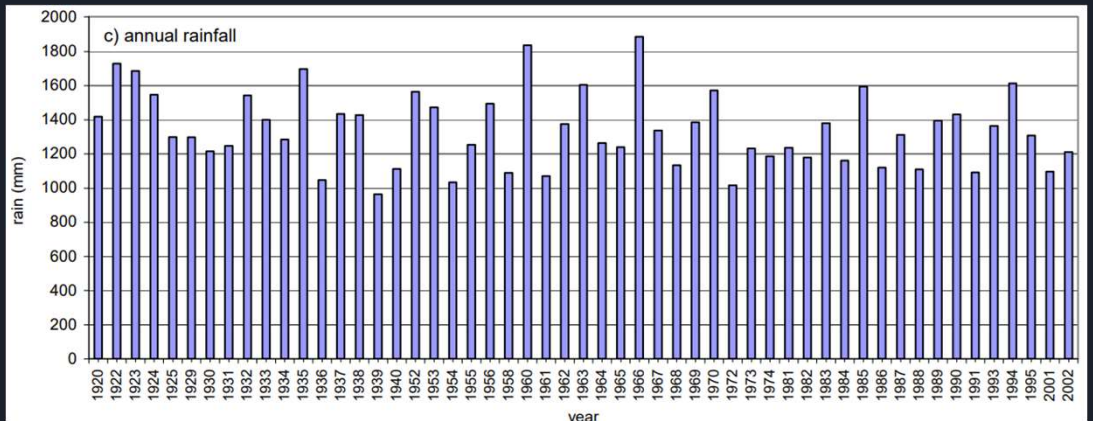


# Proposal of Rainwater System

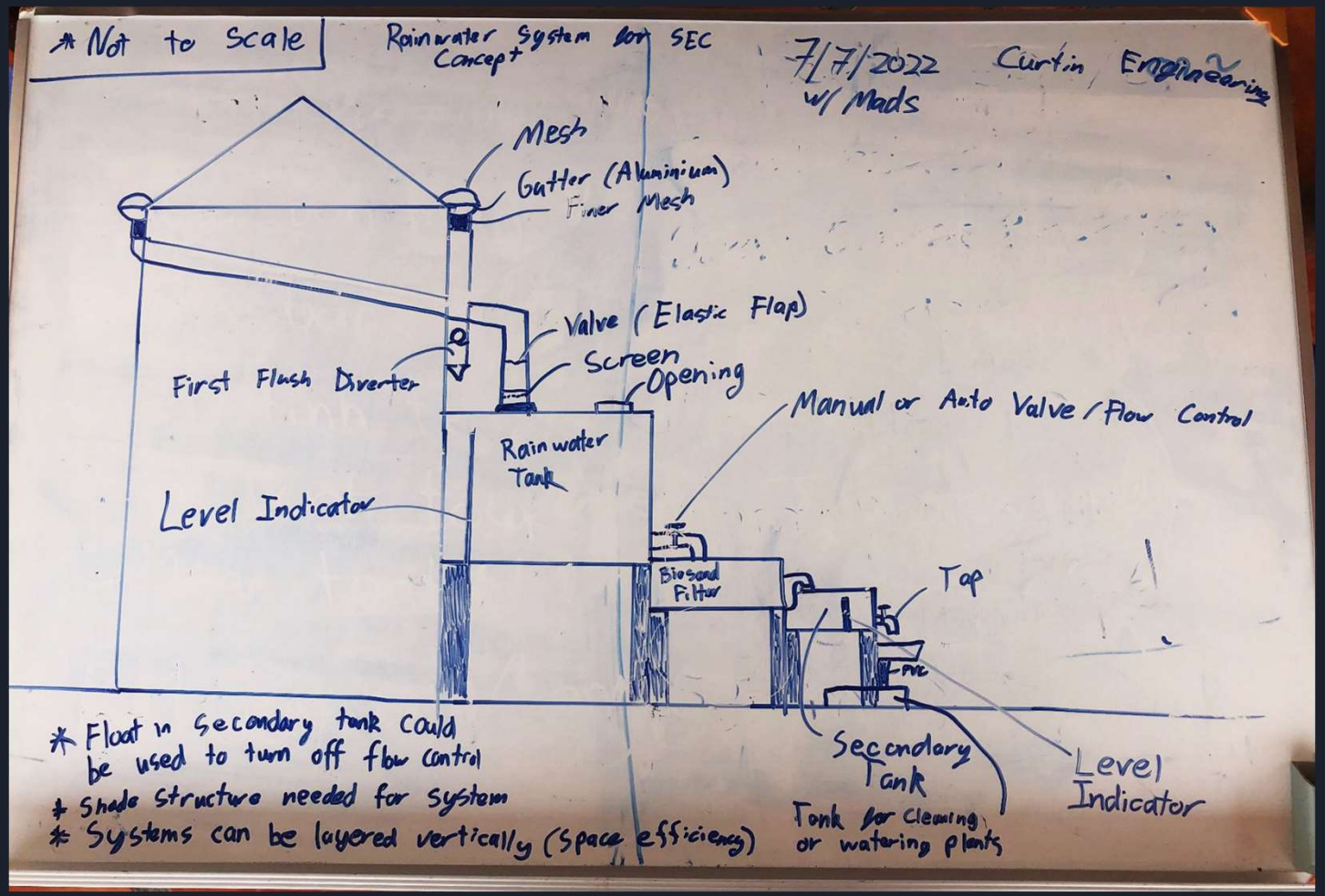
Eutrophication and pollution in canals make water source unviable. A contaminated water table further makes bore water & aquifers unviable. The other available long term solutions involve rain water or highly advanced filtration systems.  In the interest of cost rainwater has been investigated.

It is difficult to predict the future trend of weather patterns, however, community engagement, a research paper from Murdoch University (from the Mekong River Commission) and climate data suggest that there is sufficient rainfall in the wet season to support water supplies for the duration of the year. Cambodia's tropical weather means that it receives more rain from a more accelerated water cycle, but its evaporation rate is also high.

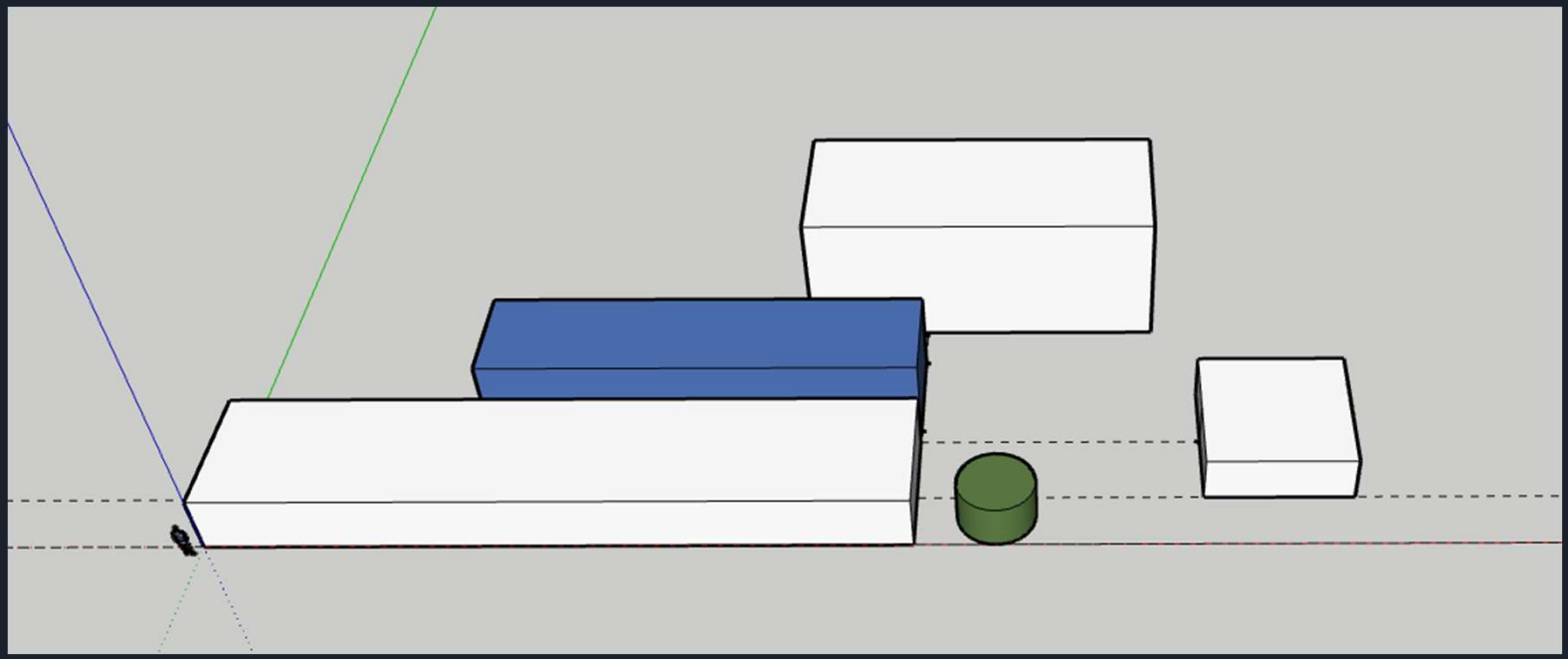
If this rain was able to be collected it could be an alternative. A rainwater system would require an investment in infrastructure for its collection, storage, filtering, maintenance and testing.



# Conceptual Sketch

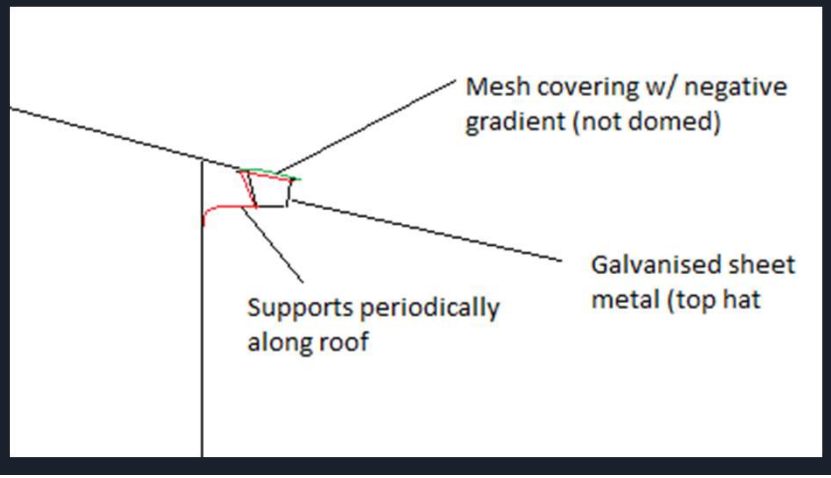


# Layout of SEC w/ proposed location of tank



# Rainwater Collection

- The facing sides of the early childhood building, the main building and the classrooms under construction have an estimated cross sectional area of roofing of 412 metres squared.
- Galvanised steel will be required for the gutters on each building. Split bamboo can be a temporary fix. The gutters will need to be made of approximately 2mm x 350mm galvanised sheet in a top-hat shape.
- PVC pipes will need to utilized as downpipes and pipes across buildings with a 150-175mm diameter. Steel brackets will be required to attach the downpipes and gutters to the structure.
- Overall Estimated Quantities: Galvanised Steel Sheet (~126m) Steel Brackets (>45)
  PVC (>60m) PVC Joins/Bends (>15)




The roof area is estimated to be: 412 metres squared
(Main-238, New-135, Facing Early Childhood-39.4)

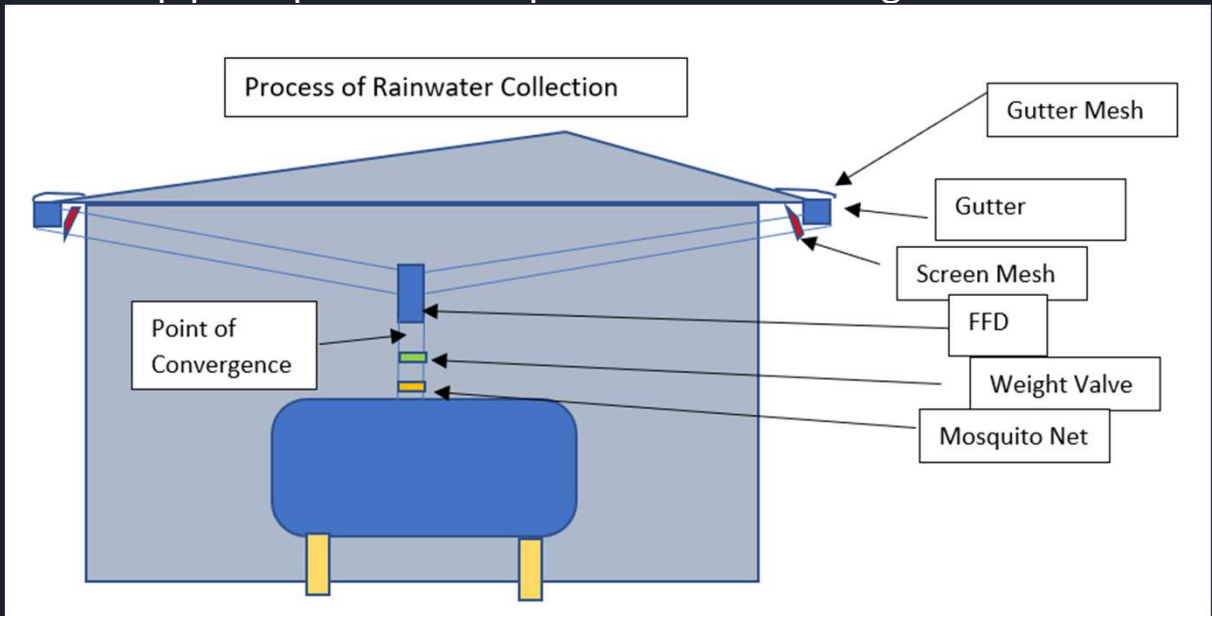
With the annual rainfall measurement used being 1000mm/year and the ROC being 0.8 the approximate volume of water is estimated to be: 329,600 L
Accounting for water remaining in gutters & PVC pipes this value has been reduced to be: 325,000 L (4,600 L lost)

# Preliminary Filtering

- Mesh to prevent foliage blocking downpipes. Negative gradient (shown previously) so wind can blow dry leaves off roof.  Bolted to the gutter/bracket in ~2m segments so can be removed for cleaning.
- Fine fly screen mesh at the top of the downpipe as a backup for more fine debris.
- Flap valve placed above raintank after convergence. Allows weight through but close when no force is on it (like those in veins/in portable toilets). Prevents small debris & insects in dry periods.
- Mosquito screen can be placed in the pipe to prevent mosquitoes from entering. Also in overflow pipe.

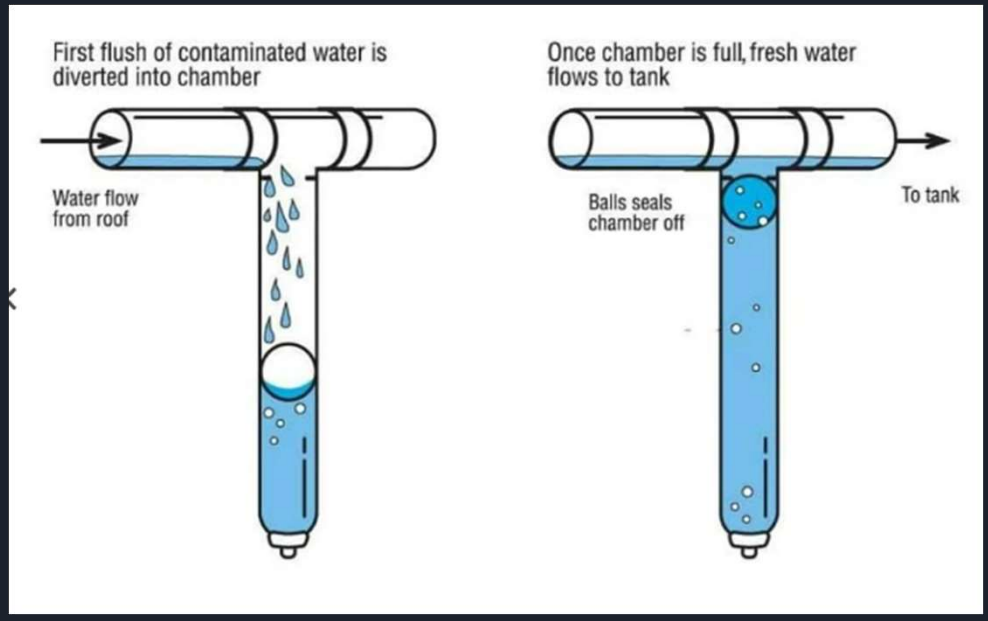
Estimated Quantities: ($180)

- Gutter Mesh- (~126m*0.12m) $120
- Screen Mesh-(4*240cm^2) $10
- Valve- (2*240cm^2) $24
- Mosquito Net- (2*240cm^2) $20



# First Flush Diverter

- A device which redirects the first 1-2 mm of rain in order to prevent fine dust, dirt or pollution particles from entering the storage tank
- This is device would minimise and prolong the maintenance of the tank.



# Rainwater Storage Capacity

- 520 people use the water at the school
- Assume 750mL per day per person
- Approx. 1,950L per week
- Can go up to 2 months without rain in the dry season, so we need 8 weeks worth of water storage (15,600L)
- Due to this, we chose 20,000L capacity tank
- During wet season, the tank may overflow, however this is not an issue, as long as it is full enough for the dry season
- Additionally, water can be stored in 20L bottles in the wet season to have a prolonged supply for dry season

# **Rainwater Storage** Option 1: Two 10,000L 3 Layer Impact Water Tank



Source 1: https://www.impactsales.in/tripple-layer-10000.html#water-storage-tank

- Dimensions of Tank
  - Diameter: 83 inches ⇒ 2.11 meters
  - Height : 114 inches ⇒ 2.90 meters
- Dimensions of Lid
  - Lid = 18 inches ~ 0.5 meters
- Storage Capacity: 10,000 Litres
  - Two water Tanks ⇒ 20,000 Litres
  - Material → Thermoplastic Plastic
    - PPFRP
    - FRP
- Wholesale Price: 59,000 (INR) ⇒ 745 USD
  - For two water tanks 1490 USD
  - Contact Seller to get a cheaper price!
    - Anoj Kumar  Call +91-8046072968}
    - Impact Sale Corporation { Call +91 8046072968}
  - Sold by: Indiamart, Impact Sales,  India, Raigad Maharashtra
- Shipping
  - Services: HeavyHaulers, FedEx, ups, USPS.com, DHL.
  - 40 foot container can carry 27,000 KG

# **Rainwater Storage** Option 2: Four double layered 5,000L Tanks

**Diamond Plastic Vertical Water tank 5000L**


- Dimensions of Tank
  - Diameter:  1.72 meters
  - Height :  2.30 meters
- Storage Capacity: 5,000 Litres
  - Four water Tanks ⇒ 20,000 Litres
  - Material → Marble
- Wholesale Price: Need to contact seller*
  - Contact Seller to get a more cheaper price!
    - Email:  info@songfawatertanks.com
    - { Call +855 923 33000}
  - Sold at: #277Eo, Street 128, Khan 7 Makara, Phnom Penh
- Warranty
  - 15 Years

**Source 2:** http://www.songfawatertanks.com/en/products-detail/d-plastic-vertical-water-tank-5000l

# **Rainwater Storage** Option 3: Cambodia H2O


Based in Phnom Penh

Can deliver to Battambang

Has a 20,000L Option

Unknown price, quote needed

# Filtering Options

WATEROAM PLUS

BIOSAND FILTER

LIFESTRAW COMMUNITY

# **Filter Options:** Wateroam Plus

**Cost**

- The filter cost $350 USD
- Membrane can be replaced every 2 years at a fraction of the price

**Effectiveness**

- Removes 99.9999% of bacteria
- Removes 99.99% of viruses

**Key Advantages**

- Membrane lifespan of 2 years
- Filters 1,400,000 liters of water
- Manual flow rate of 200L/hour
- Gravity fed/Electrical flow rate of 400L/hour

# Operational Methods:

The most sustainable method suitable with the approach we are suggesting would be the Direct Sink method. The  filter can be directly attached to the rainwater tank. Utilizing the water pressure from the tap, water can be filtered through the system

## Hand Pump

The system mimics the mechanics of a bicycle pump. Users simply needs to pump the system in a consistent up-down motion.

## Direct Sink

Attach the system to a tap. The water pressure from the tap will allow water to be filtered as it flows through the system.

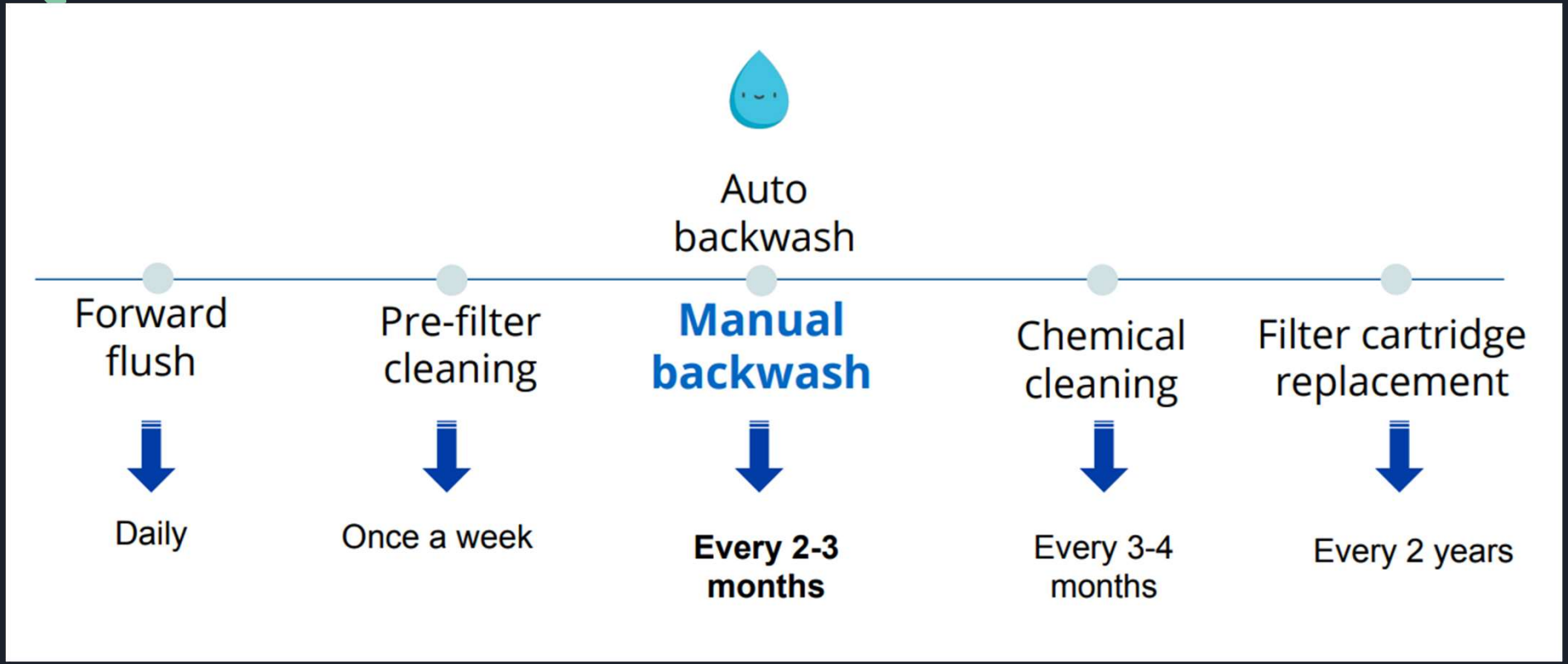
## Gravity-Fed

Attach the system to an elevated tank (optimally 3 to 5 metres). Allow water to flow through the system.

## Electric Pump

Attach the system to a electric pump and allow water to be filtered as it flows through the system.

# **Wateroam -** Maintenance



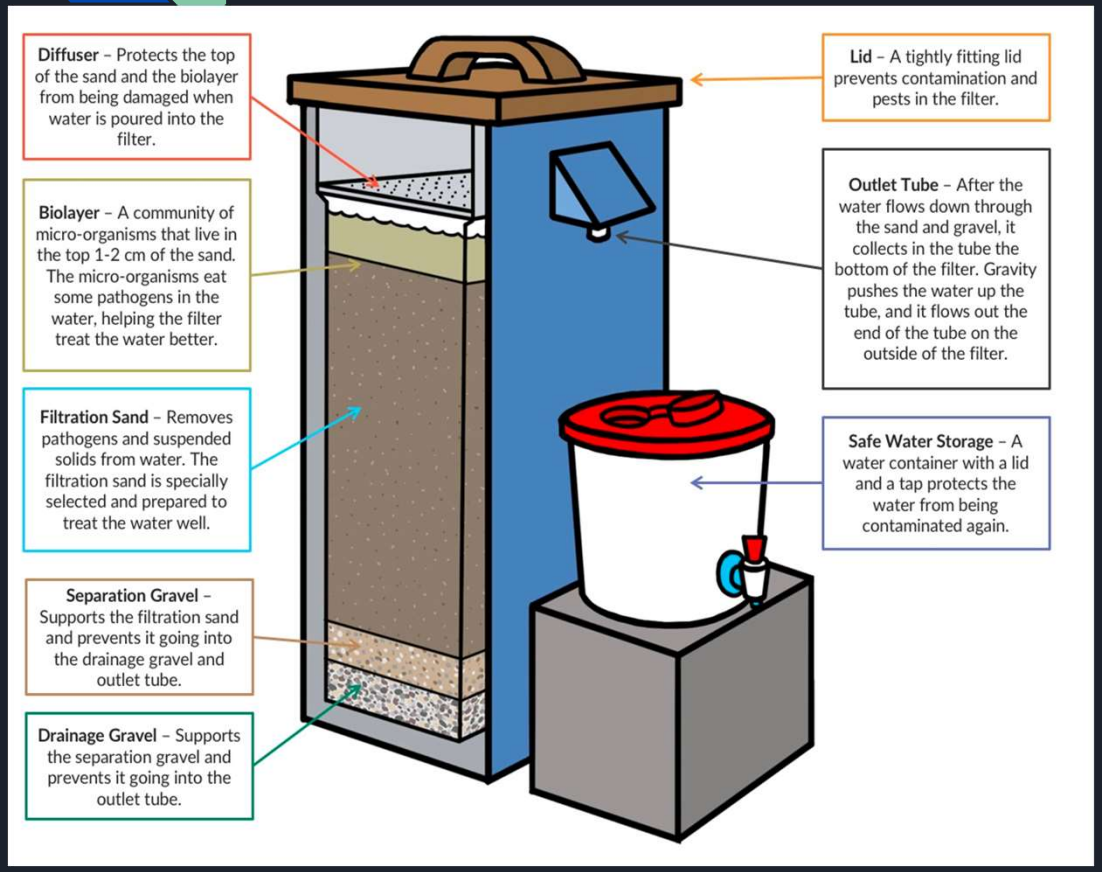
# **WaterRoam** - Pros & Cons

| Pros | Cons |
| --- | --- |
| - Water Roam started in 2014 and currently deployed in 38 countries<br>- Easy Installation<br>- Already implemented in Kampon Thom including 2 school districts in Baray District<br>- Don’t need any water storage as it filters directly from the rainwater tank to the Roam Water tap<br>- Multiple pumping methods that allows water to be fed through gravity or manually | - The logistics and distribution cost might be higher due to the lack of warehouses overseas<br>- Lifespan of membrane is 2 years<br>- Regular maintenance is required however it is not too complex |

https://www.wateroam.com/roamfilter-plus-video-tutorials.html

https://aim2flourish.com/innovations/roaming-to-bring-water-to-the-world

# **Bio-Sand Filtering System** - How it works




- Each Filter is constructed with layers of Gravel and Sand
- The collected Rainwater is passed through the diffuser plate which will then stream through the biosand
- The sand surface consumes harmful bacteria and other pathogens including parasites, viruses, certain organic compounds by attaching to the sand through a process called absorption
- Once the water reaches the lower levels, the oxygen levels will diminish the organism causing it to die a natural death
- Clean drinking water will then pour through the spout

https://www.waterforcambodia.org/biosand-filters.html

# BioSand Filtering System

**Cost (based on Clear Cambodia Installation Pricing):**

- Clear Cambodia requires school to make an investment into the project
- The school will contribute between $400-$1,000 for the shelter to protect the tanks
- If water Latrines are to be included then cost of $200-$300 depending on the size of the school

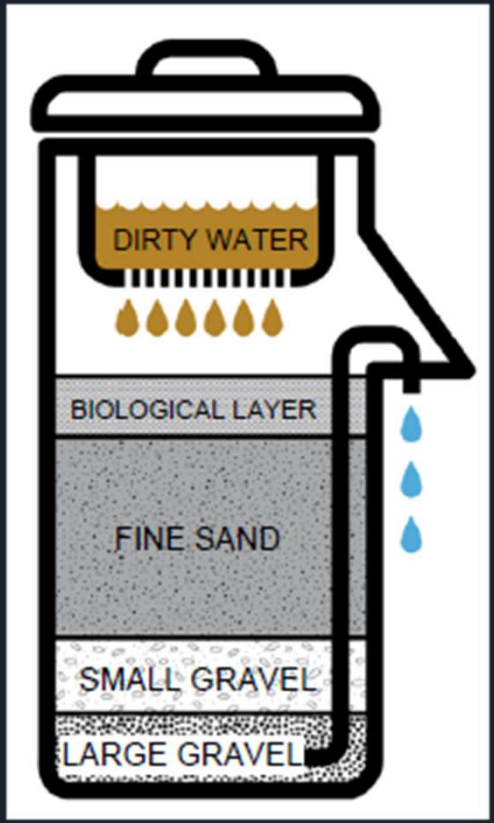
**Effectiveness**

- Removes up to 90% viruses
- Removes up to 98.5% Bacteria
- Removes up to 99.9% of protozoa
- Removes up to 95% turbidity
- Removes up to 90-95% of iron

https://www.clearcambodia.org/school-wash-program/

# **Bio Sand Filtering System** - Pros & Cons

| **Pros** | Cons |
| --- | --- |
| - Biosand Filters have already been implemented in Cambodia through Clear Cambodia<br>- Low maintenance<br>- Lifespan of the filter is up to 15 years<br>- Easy to install | - Does not remove all contaminants<br>- Slow Filtration<br>- Limited capacity in Water Storage<br>- Filter is heavy and difficult to move around |



# LifeStraw Community

**Cost**

> $395USD for the community lifestraw

> $49.95USD for replacement filter every 100,000L

**100,000L will last approximately one year for drinking purposes only.

**Effectiveness**

- Removes 99.9999% of bacteria
- Removes 99.99% of viruses
- Removes 99.9% of protozoan parasites
- Removes Turbidity to 0.2 microns


# **LifeStraw -** Pros & Cons

| **Pros** | **Cons** |
| --- | --- |
| - Filter is easy to clean<br>- Requires no electrical power, batteries or replacement parts<br>- 3 star performance from WHO tests<br>- Comprehension protection: very high removal of bacteria, viruses and protozoa | - Filter requires replacements every 100,000L<br>- Replacements usually ordered from the US: may produce challenges<br>- Cannot change the pH of the water<br>- Requires bottle of unfiltered water to be continually filled up |

# Minor Components of System

- Concrete and/or bricks to be laid where tank and filter will go so it is on stable foundation.
- Shade cloth/structure need to be placed over tank so PVC & components for not overheat or be exposed to UV.
- Elevate tank on metal and/or concrete (>0.5m) to allow the filter to work with gravity.
- Have manual valve underneath tank to allow drainage of sediment.
- Overflow pipe needs to flow from tank to current drainage system (aprox. 5m underground pipes) to prevent erosion.
- Sink under filter into 20L  catchment tank to be used for cleaning & vegetation - to prevent water on ground around tank.
- Manual valve/tap between tank and filter to turn water on/off
- Water indication line on side of tank so water level can be observed

# Maintenance of System

| Equipment/Item | Equipment Needed | Maintenance Period |
|---|---|---|
| Gutters/Fine Mesh | Scrub Brush (To remove debris and bio-film) | 6 months<br>(Before and after wet season) |
| First Flush Diverters | Scrub brush | 6 months<br>(Before and after wet season) |
| Tank | Broom/brush, water to rinse | Every 2-3 years<br>(Start of Wet season) |
| Secondary tank (If used) | Scrub Brush | 6 months |
| Wateroam | Membrane Filter | 2 years |
| Repainting PVC pipes | Light coloured paint, primer and sandpaper | 5-10 year depending on level of sun exposure |

# Maintenance: Tank Disinfection

- Using Chlorine dioxide tablets (1 per 100g tablet for 10,000L)
- Does not release dangerous gases
- Still effective and safe in excess and limited amounts
- Company willing to ship bulk amounts to Cambodia
- Controls bacteria, fungi, viruses, biofilm and algae
- Recommended by the World health organisation
- Every 3-6 months


NaturalWater SOLUTIONS

# Testing options for drinking water

## Aquagenx- E.coli and Coliform test(CBT EC+TC KIT)

- Chapel Hill,North Carolina, USA
- https://www.aquagenx.com/cbt-ectc/

## Varify - Complete drinking water test kit

- San diego, California, USA
- https://varify.com/collections/drinking-water-tests/products/complete-drinking-water-test-kit#

## Wateroam - Coliform Test Kit

- 71 Ayer Rajah Crescent, #07-01, Singapore
- https://wateroam.myshopify.com/products/aquavial-water-test-kit

## Water for Cambodia - Lab test

- Group 18, Tropeang Seh Sangkat Kour Chork, Siem Reap, Cambodia
- https://www.waterforcambodia.org/water-testing-lab.html

# **Aquagenx** - CBT EC+TC Kit

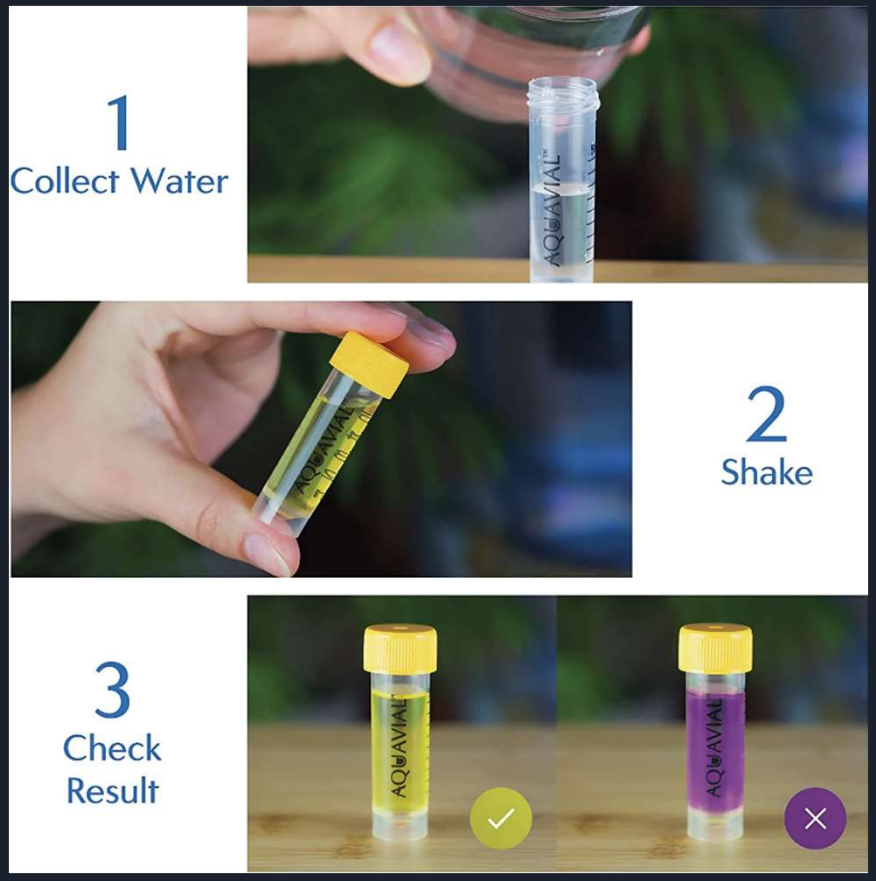
| Pros | Cons |
| --- | --- |
| • Indicates the Presence or Absence of E.Coli and Total Coliforms.<br>• Color change test results for easy interpretation<br>• 25 tests in a pack<br>• $10 per test | • 20-48hrs wait at above 25c for results<br>• Cost $249.01 inc shipping to battambang<br>• UV light required for some results<br>• 2 year shelf life |

# **Varify** - Complete Drinking water test kit

| Pros | Cons |
| --- | --- |
| • Gives results for 16 different Parameters, including Coliform, Nitrite,Nitrate and common metals<br>• Cost $55.90 inc shipping to battambang<br>• Color change test results for easy interpretation | • 48hr at 20-32c wait for coliform results<br>• Does not test for E.coli<br>• 2 bacteria tests included |

# **Wateroam** - Coliform Testing kit

| Pros | Cons |
| --- | --- |
| • Indicates presence of e.coli or coliforms<br>• Cost $63.53 inc shipping to battambang<br>• Color change test results for easy interpretation<br>• $7.95 per test | • Results take 48hrs |



# **Water for Cambodia** - Testing facility

| Pros | Cons |
| --- | --- |
| • Gives results for 9 different parameters including e.coli, Coliform, nitrates and water hardness<br>• Test performed by lab technicians | • Lab is located in Siem Reap<br>• Sample must be transported to lab<br>• Costs $44 per test |

# Estimation of Costings - Upfront

| Item | # of Items | Unit Cost (USD) | Shipping cost (USD) | Total (USD) |
|---|---|---|---|---|
| First Flush Diverter | 3 | 125.60 | 0 | 376.80 |
| Water Tank | 2 | 745 | Cambodian | 1490 |
| Insect Screen Cloth | 1*(30inx7ft) | $10 | Cambodian | 10 |
| Gutter Mesh | 21*6m | $5 | Cambodian | 105 |
| Mosquito Screen | 2 | $10 | Cambodian | 20 |
| Flap Valve | 2 | 12 | 2 | 26 |
| PVC Pipe (6m, 6in) | 10 | 3.77 | Cambodian | 37.70 |
| Brackets (100ft steel hanger strap) | 1 | 25 | 5 | 30 |

# Estimation of Costings - Upfront (cont.)

| Item | # of Items | Unit Cost (USD) | Shipping cost (USD) | Total (USD) |
|---|---|---|---|---|
| Galvanised Steel Sheet (Gutter) | 44.1 metres squared | 36.10 | 20 | 1620 |
| Valve (bottom & filter) | 2 | 9.99 | Cambodian | 20 |
| Concrete Foundation (bags of cement) 4m x 7m x 0.15m slab | 18 | $101 | Cambodian | 1818 |
| Shade Structure | 1 | $304 | Cambodian | 308 |
| Sink | 1 | 30 | 5 | 35 |
| Small Catchment (20L) | 1 | 10 | Cambodian | 10 |
| | | | Total | 5905 |

According to CAD expendure this would pay for itself in 2.5 years.

# Estimation of Costings - Maintenance

| Item | Cost per unit | Cost per year |
|---|---|---|
| Chlorine dioxide Tablets | $65 | $32.50 |
| Membrane Filter | | |

# Suggestions for Consumption

- 20L Containers for when water levels are high which can be given/sold to local community or stored for dryer periods.

- Individual, reusable cups/water bottles for students in order to prevent spread of disease

# Limitations of System/Design

A key limitation of the system is the available space limits the size of the tank so only ~20,000L can be kept at once. In a dry spell this is enough for 50 school days (10 weeks). Fortunately, students are on holiday for the bulk of the dry season (November 1-Jan 11). Thus, this system will struggle in January-March where there is collectively <100mm rainfall. As a backup the current system of buying water could be used in a particularly dry March/April.

This system does not have much space for increasing tank size.

# Assumptions Made/Inaccuracies

- The measurements of the buildings at SEC seem incorrect and require further measurement, which would impact the area of roofing available and guttering required.
- The water consumption statistics are surrounded in much doubt (both drinking and hygiene). We have assumed a 400L / day average for drinking.
- The runoff coefficient of the roofs has been assumed to be 0.8

# Opportunities for Upgrade/Further Research

Upgrade the size of the tank/have another tank underground

Work with agriculture communities to reduce the fertilizer run off.

Work to reduce pollution of plastics & microplastics that go into waterways

Improve current drainage system to the west of the school

Get an additional small raintank on toilet block to provide water for flushing toilets

# Where To From Here?

- FSF to do their own cost-benefit analysis to consider viability
- SEC to approve the concept & plans
- Funding provided by FSF
- Construction crew sourced
- Construction crew to review plans and create their own drawings
- Materials to be sourced (likely at a lower price)
- Construction
- Teaching Staff instructed on maintenance procedures

# Thank you for Listening