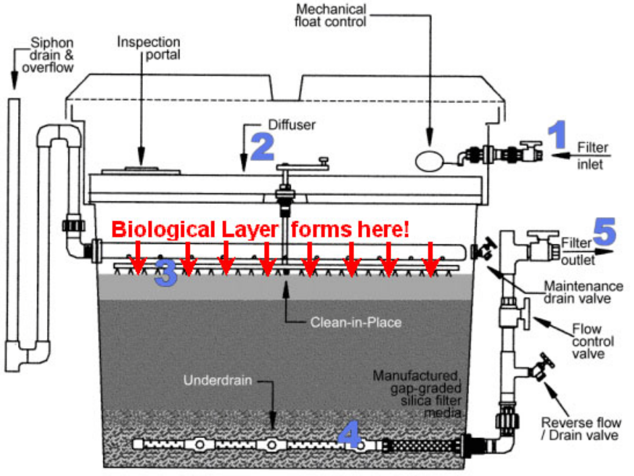
Manz Slow Sand Filter™

Manz Polishing Sand Filter™

Oasis Filter International Ltd.



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Slow sand filtration:

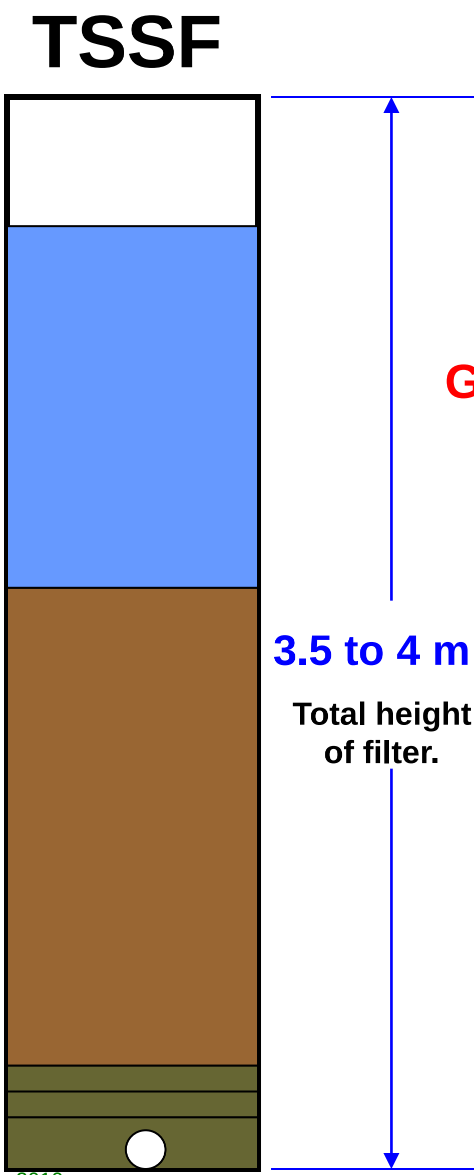
- Demand operated.
- Cleaned using backwash procedures.

Two types:

1. Manz Slow Sand Filter ™ (MSSF)
   - Fulfills process role similar to Traditional Slow Sand Filtration (TSSF).
2. Manz Polishing Sand Filter ™ (MPSF)
   - Fulfills process role of a polishing filter by exploiting unique ability of TSSF to remove small particles.

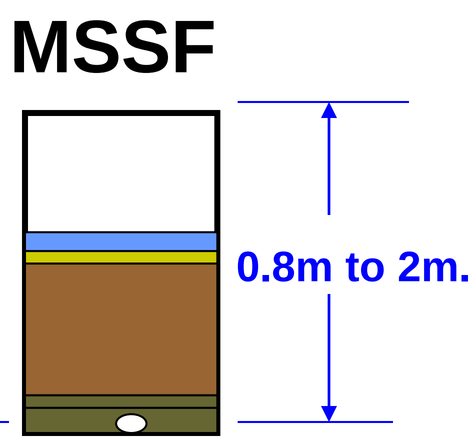
Canadian, U.S.A. and other international patents pending.

Comparison of the vertical scale of the Traditional Slow Sand Filtration (TSSF) and MSSF technologies.



All filters meet American Water Works Association Guidelines or Standards for 'slow sand filter design' and 'specification of filter media'.

Maximum Loading of 0.2 to 0.4 m^3 per hour per m^2 of filter surface as per local regulatory guidelines.



The depth of the filtering media in the MSSF equals the minimum depth recommended for the TSSF. The minimum depth is thought to be necessary for deactivation of viruses.

Comparison of Operation of TSSF and MSSF technologies

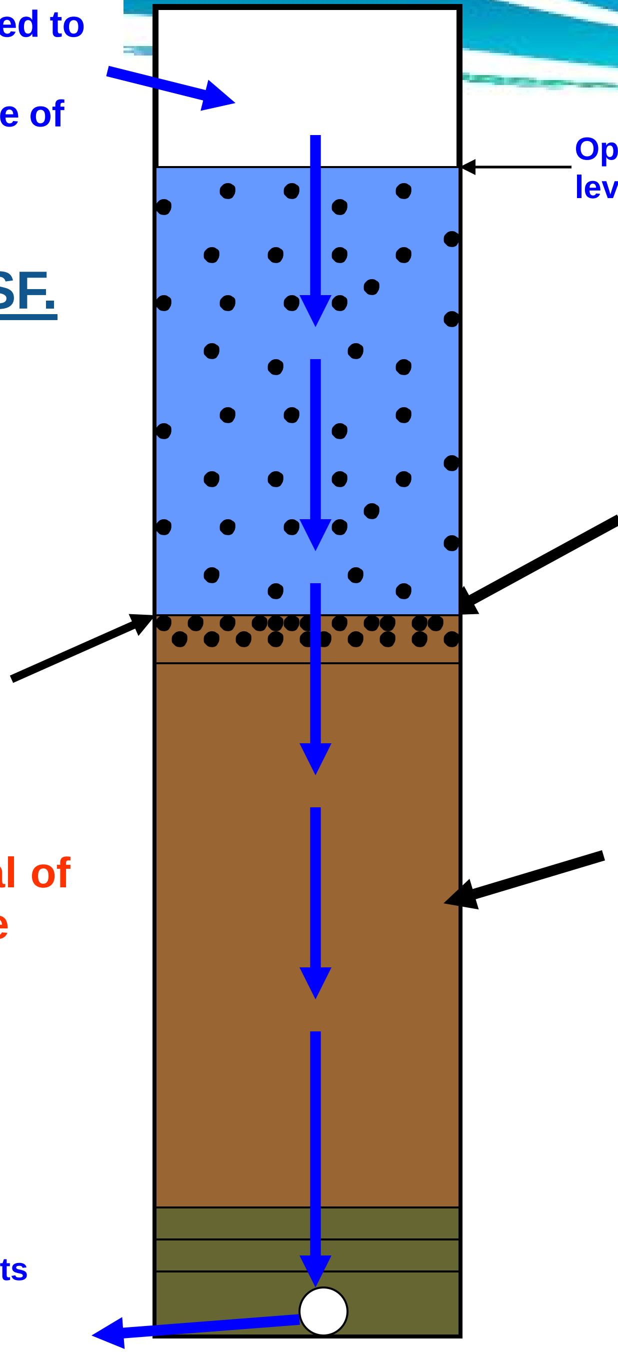
TSSF: Continuous flow – operation cannot stop or will temporarily lose ability to remove bacteria and viruses.

MSSF: Intermittent flow - operated when required (i.e. to fill treated water storage).

Also known as 'Demand Operation'.

Operation of the TSSF.

Raw water is added to filter without disturbing surface of media.



Operating water level.

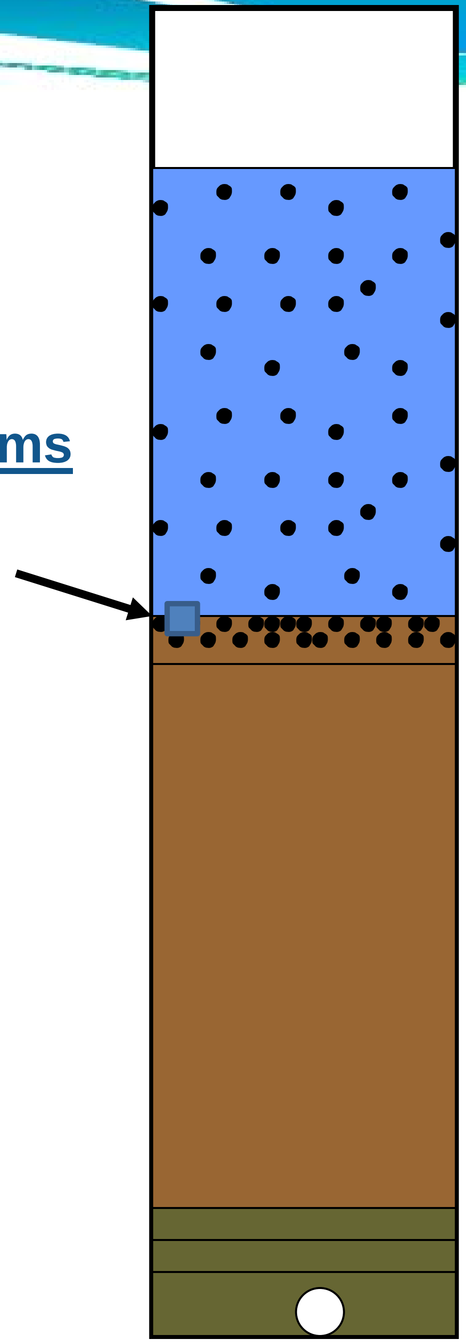
Particulate material is captured on or near surface of the very fine filtering media.

No particulate material is captured within media because the water is not <u>forced</u> into the media as it is in rapid sand filtration or pressure filtration.

Must be operated <u>continuously</u> or the biological layer or 'schmutzedeke', responsible for removal of microorganisms will be damaged or killed.

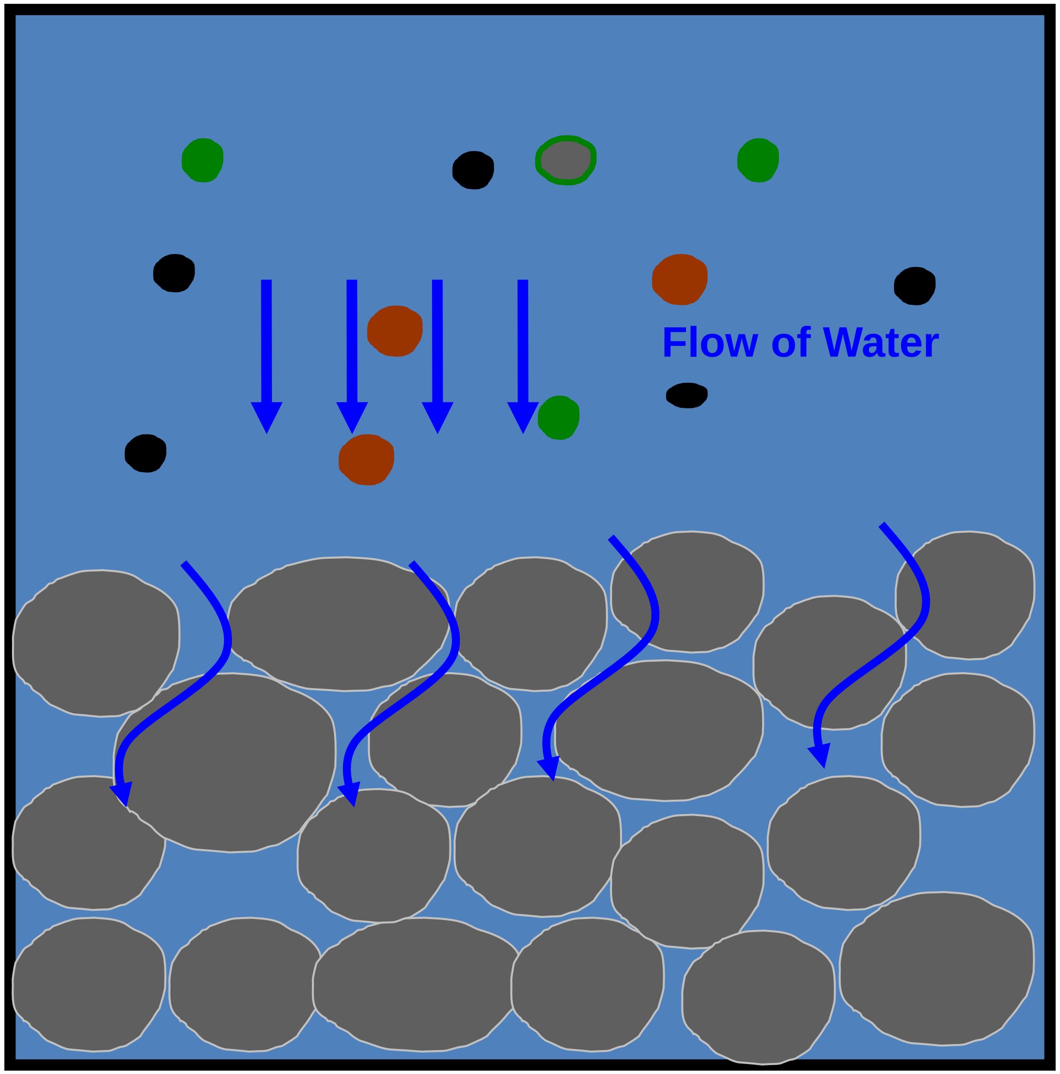
Filtered water exits filter.

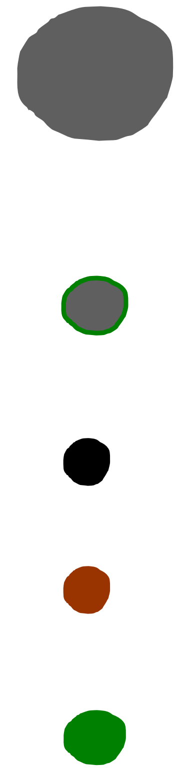
Examine the Top 1 - 2 cms of the media in a TSSF.



Operation of the TSSF.

Beginning of operation of the TSSF – no biofilm around particles and no biolayer.





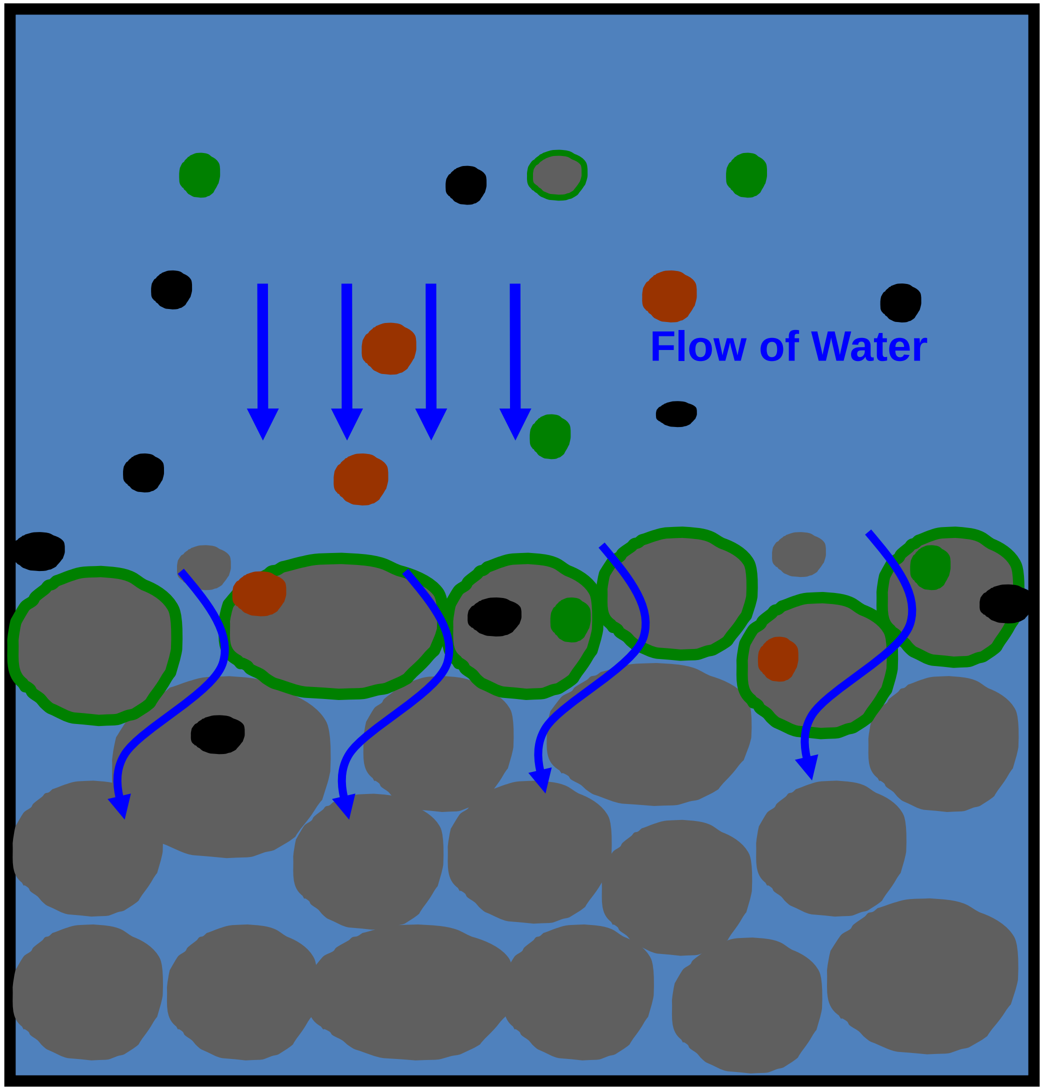
Media particle without surface biofilm.

Other mineral and organic particles or flocs of particles.

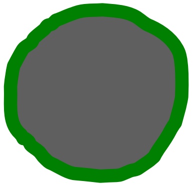
Also includes large living organisms such as algae, helminthes and the cysts of parasites.

Operation of the TSSF.

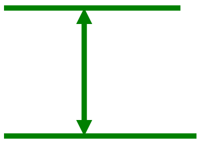
Beginning of operation of the TSSF



No biolayer is necessary for removal of parasites and larger organic material and mineral particles including oxidized iron and manganese.



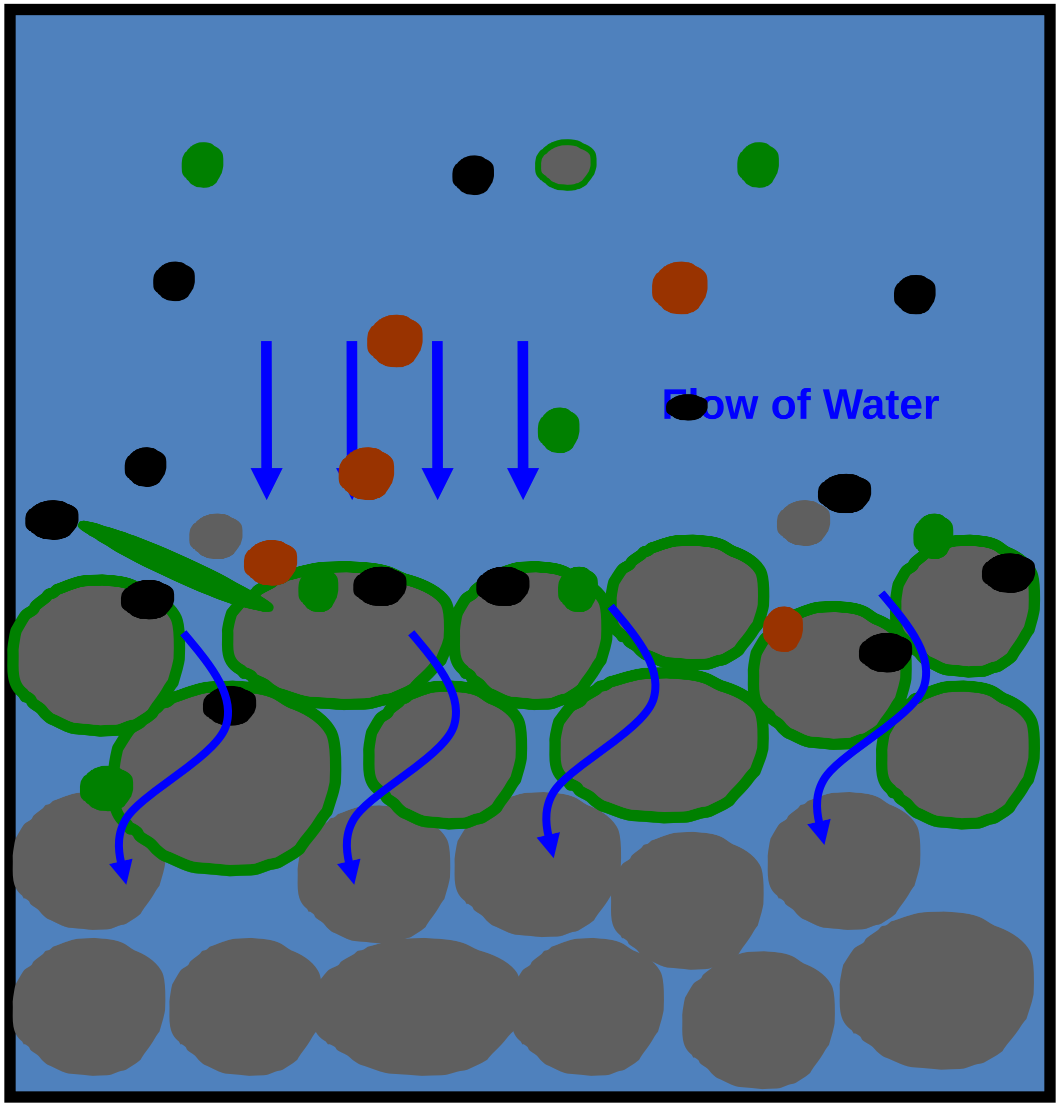
Media particle covered with a surface biofilm including bacteria and organic matter.



Biolayer (Mineral particles covered with a biofilm).

Operation of the TSSF.

Biolayer thickens with use and time.

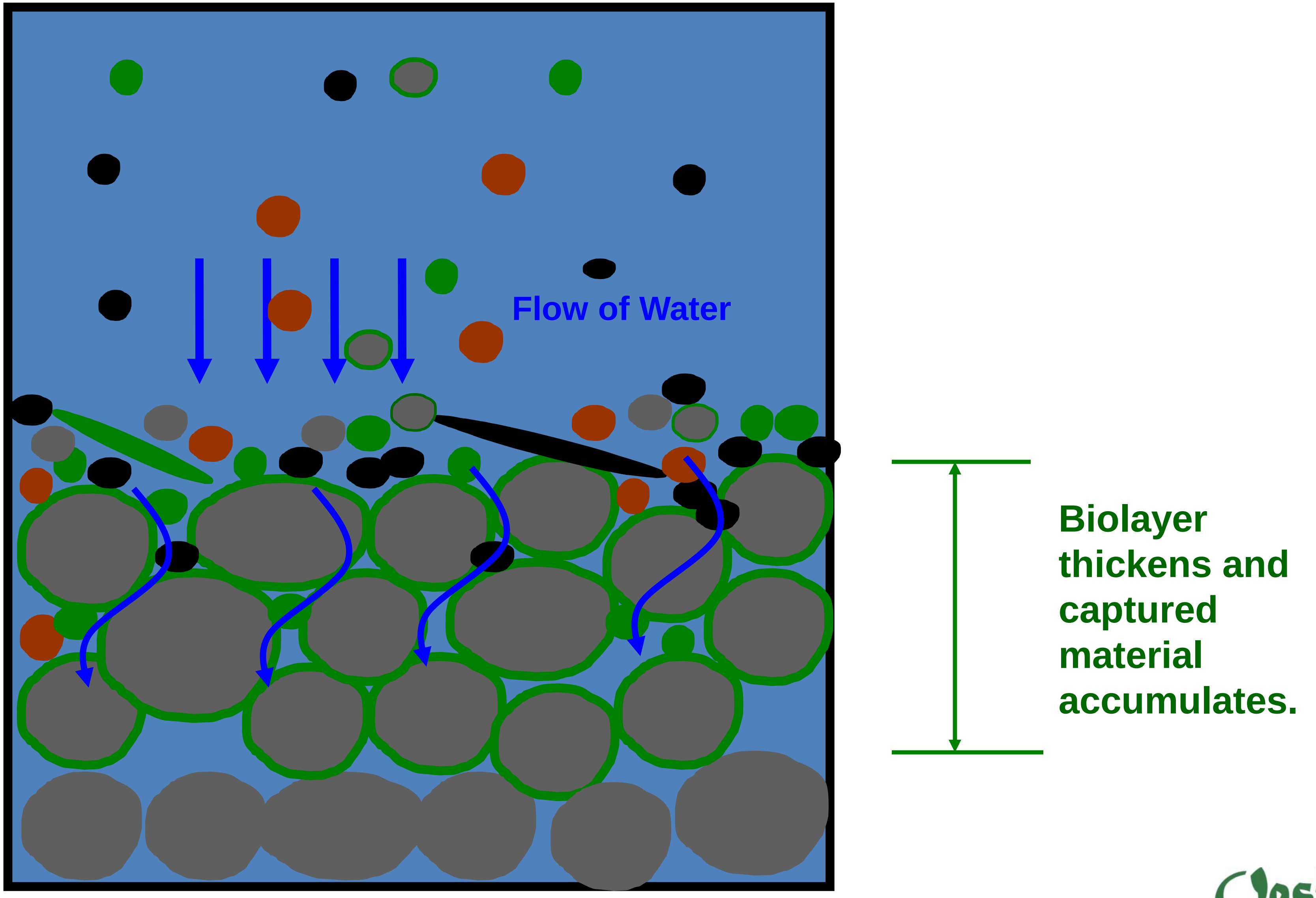


Formation of biolayer will depend on the ecology of the water being treated and the quantity of water being treated. The greater the concentration of aquatic life and the greater the quantity of water being treated the faster the biolayer will form.

Biolayer thickens.

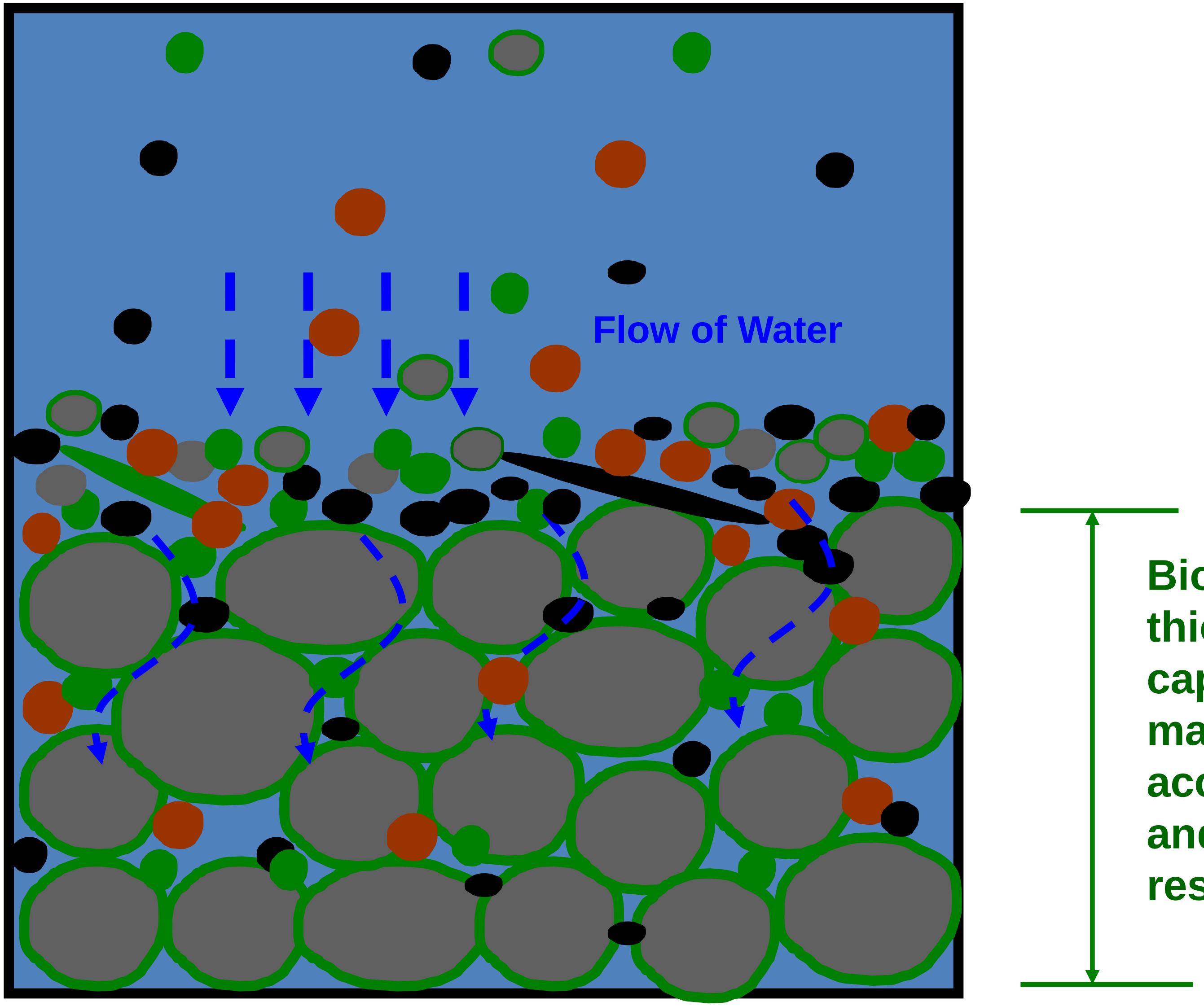
Operation of the TSSF.

Biolayer thickens with use and time.



Operation of the TSSF.

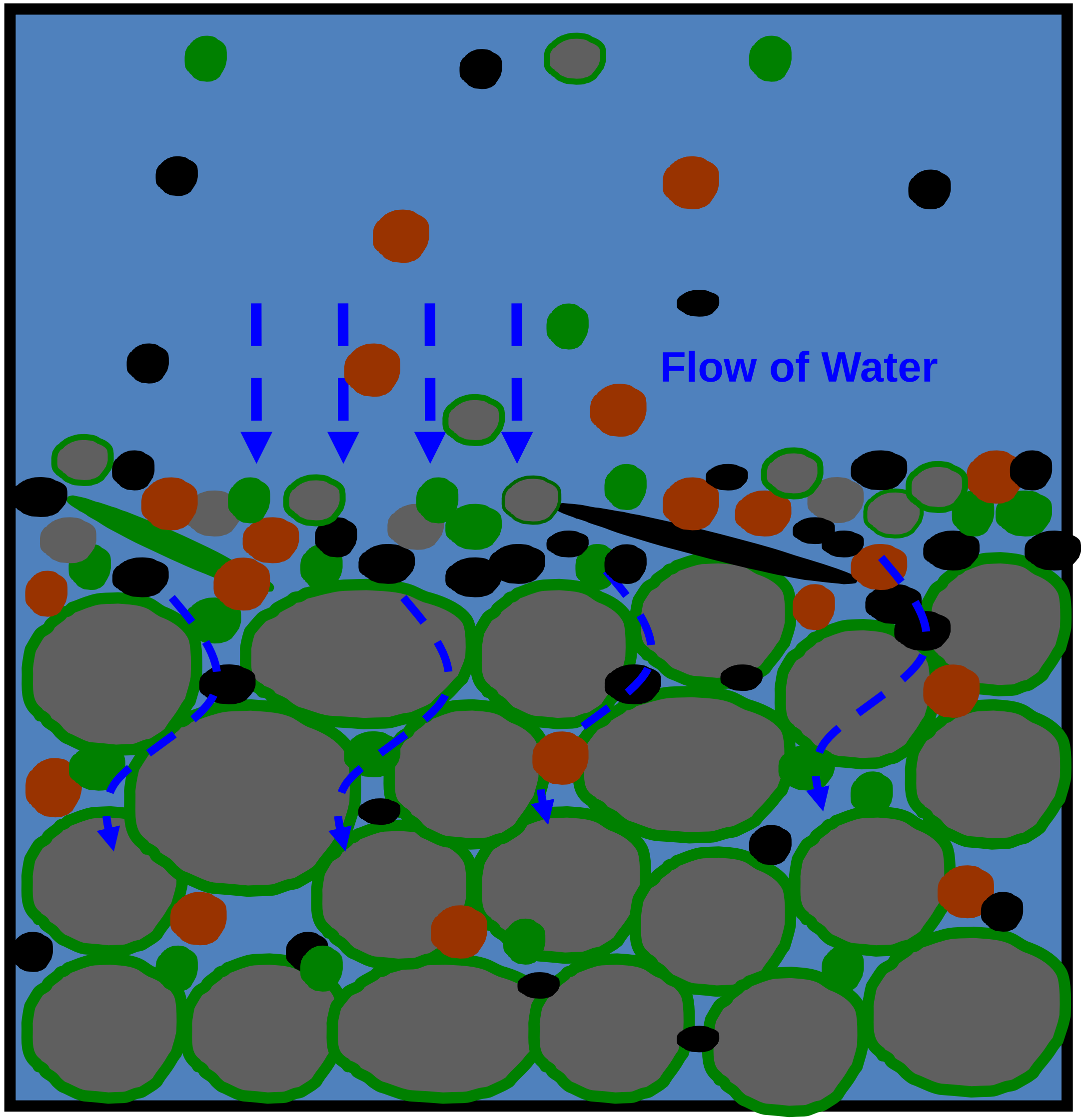
Biolayer thickens with use and time.



Biolayer thickens and captured material accumulates and starts to restrict flow.

Operation of the TSSF.

Flow is unacceptably low and filter must be scraped.



The scraping process will remove the biolayer.

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DOI: 10.2225/vol11-issue2-fulltext-12 *RESEARCH ARTICLE*

Visualisation of the microbial colonisation of a slow sand filter using an Environmental Scanning Electron Microscope

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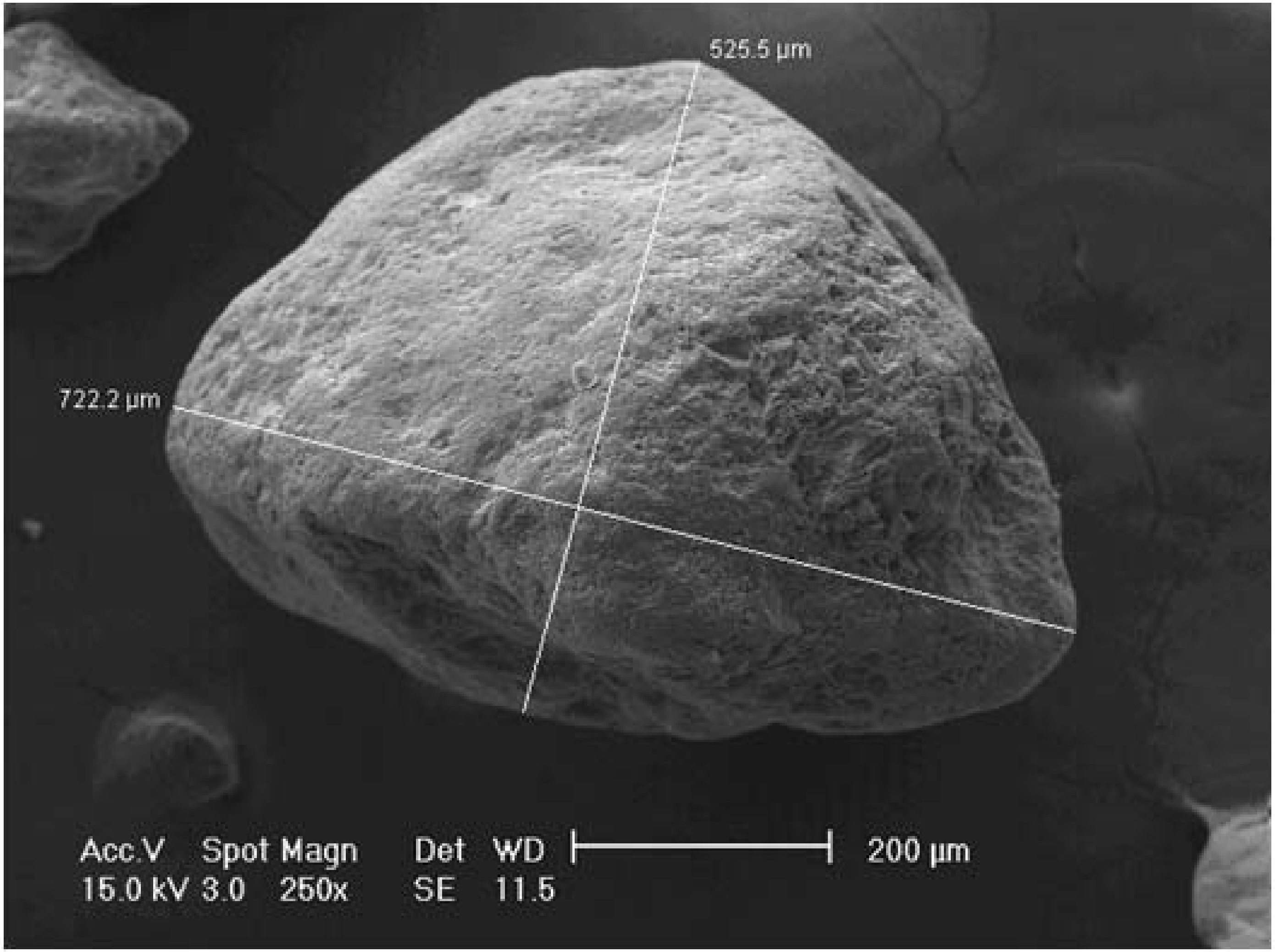
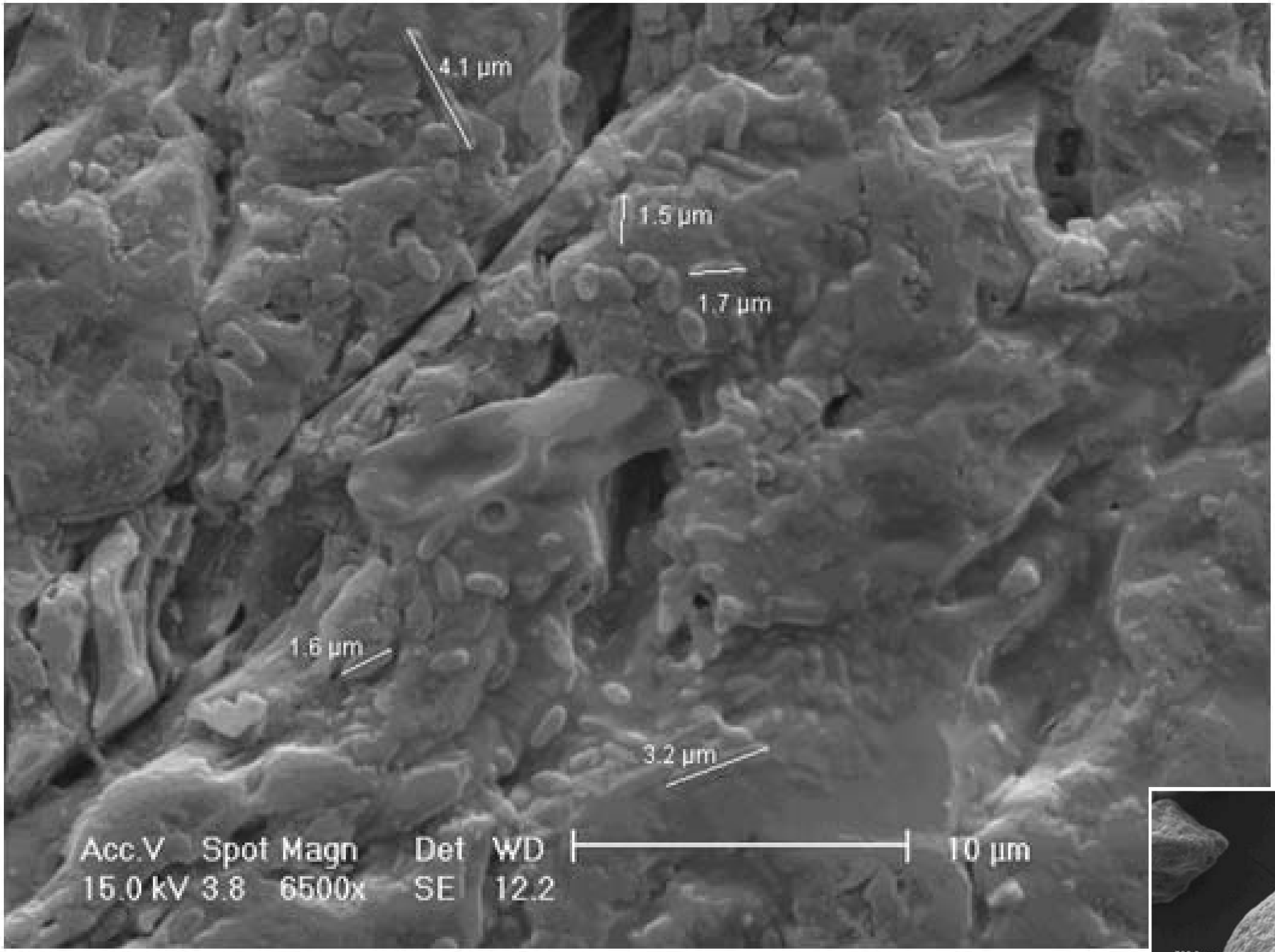


Figure 1. Micrograph of the control sample.



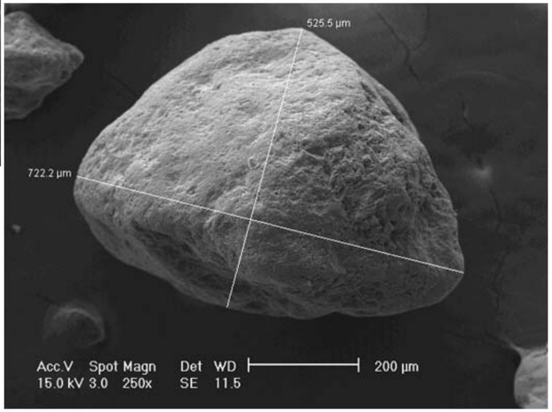
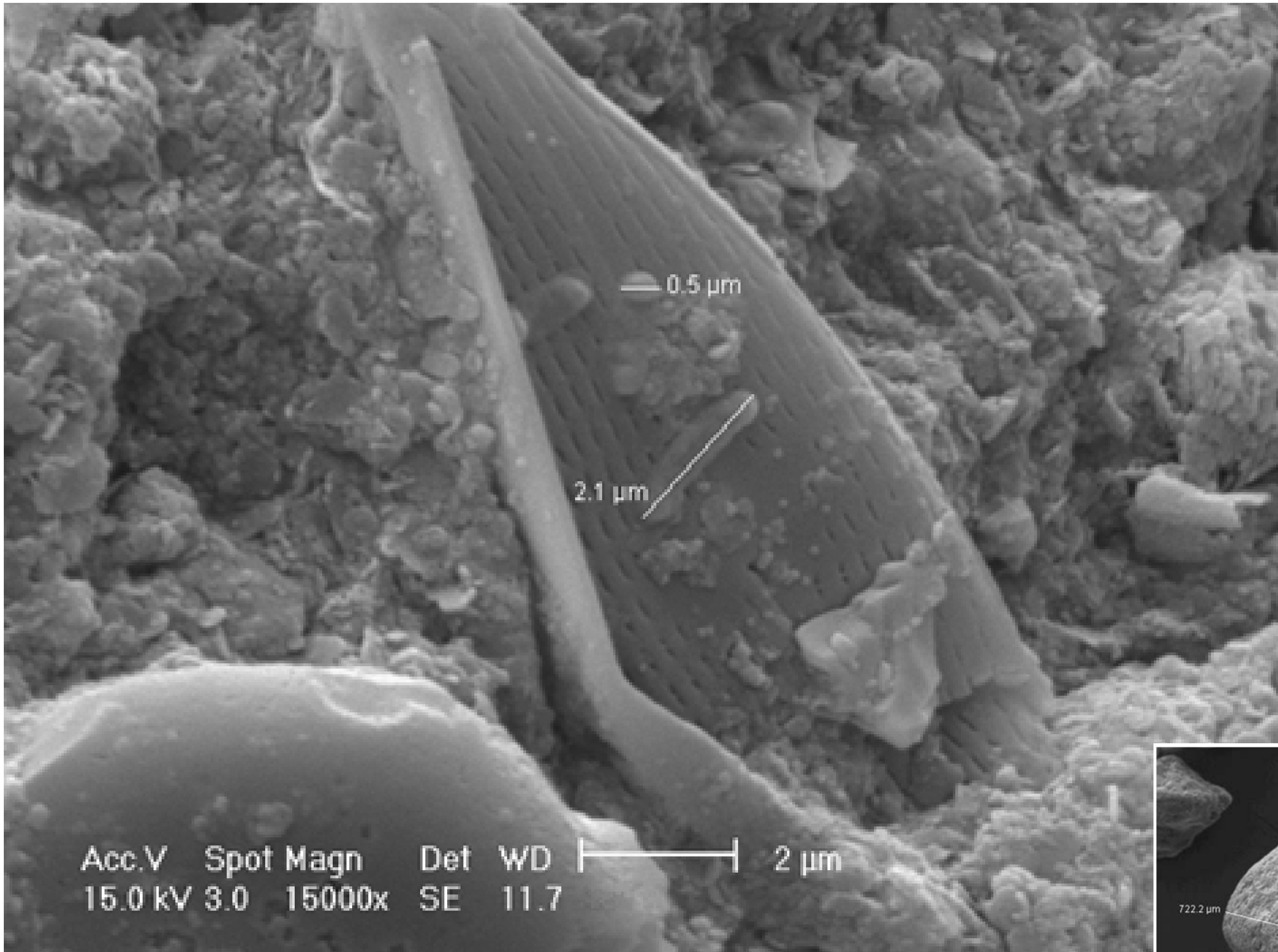


Figure 2. Micrograph of sample removed at week 1 showing a proliferation of bacteria.



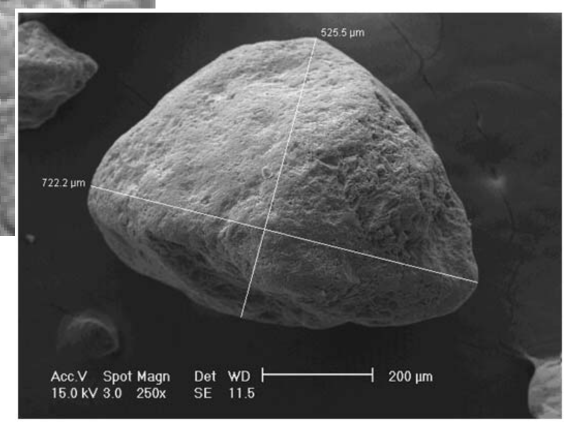
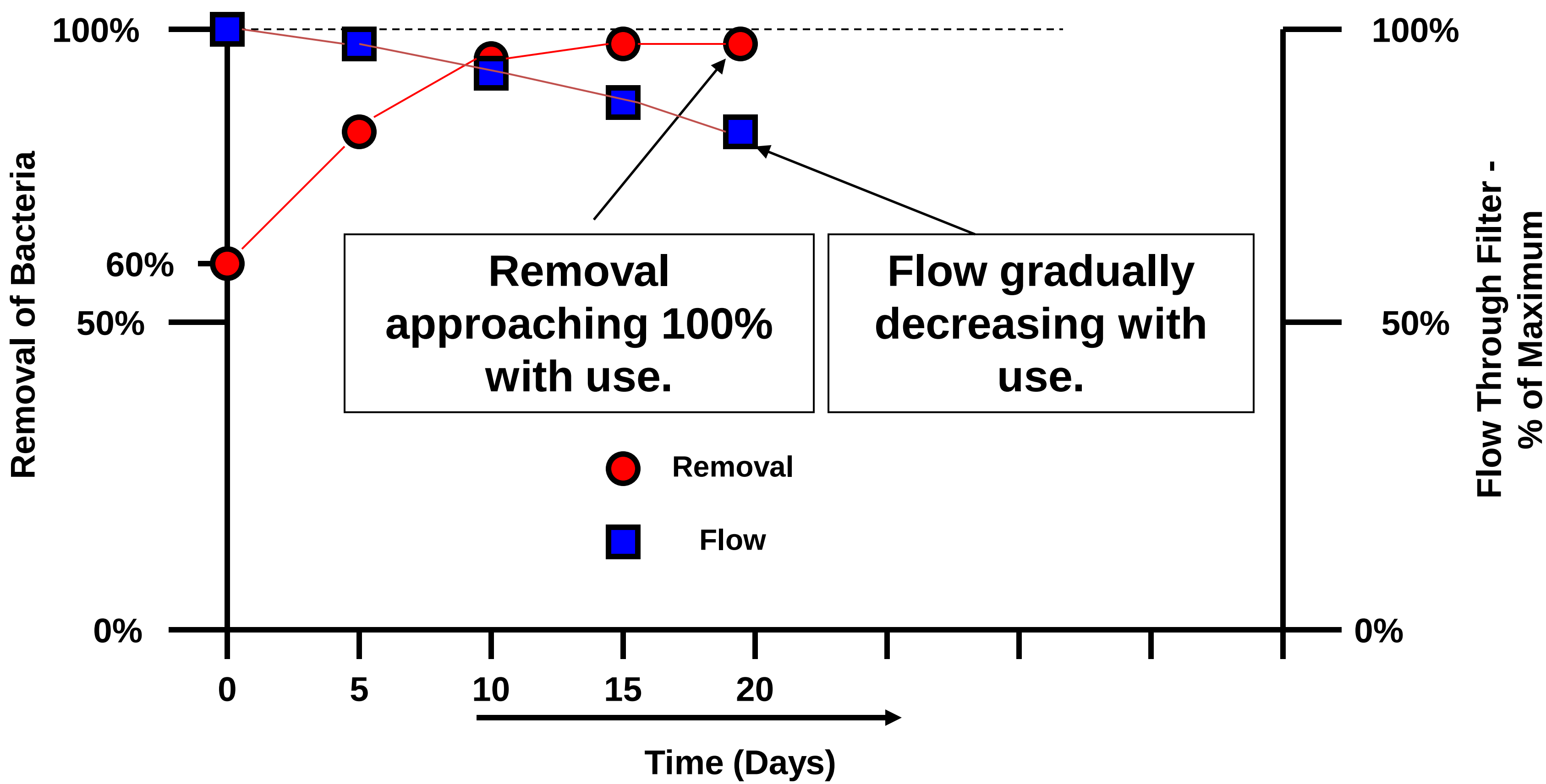
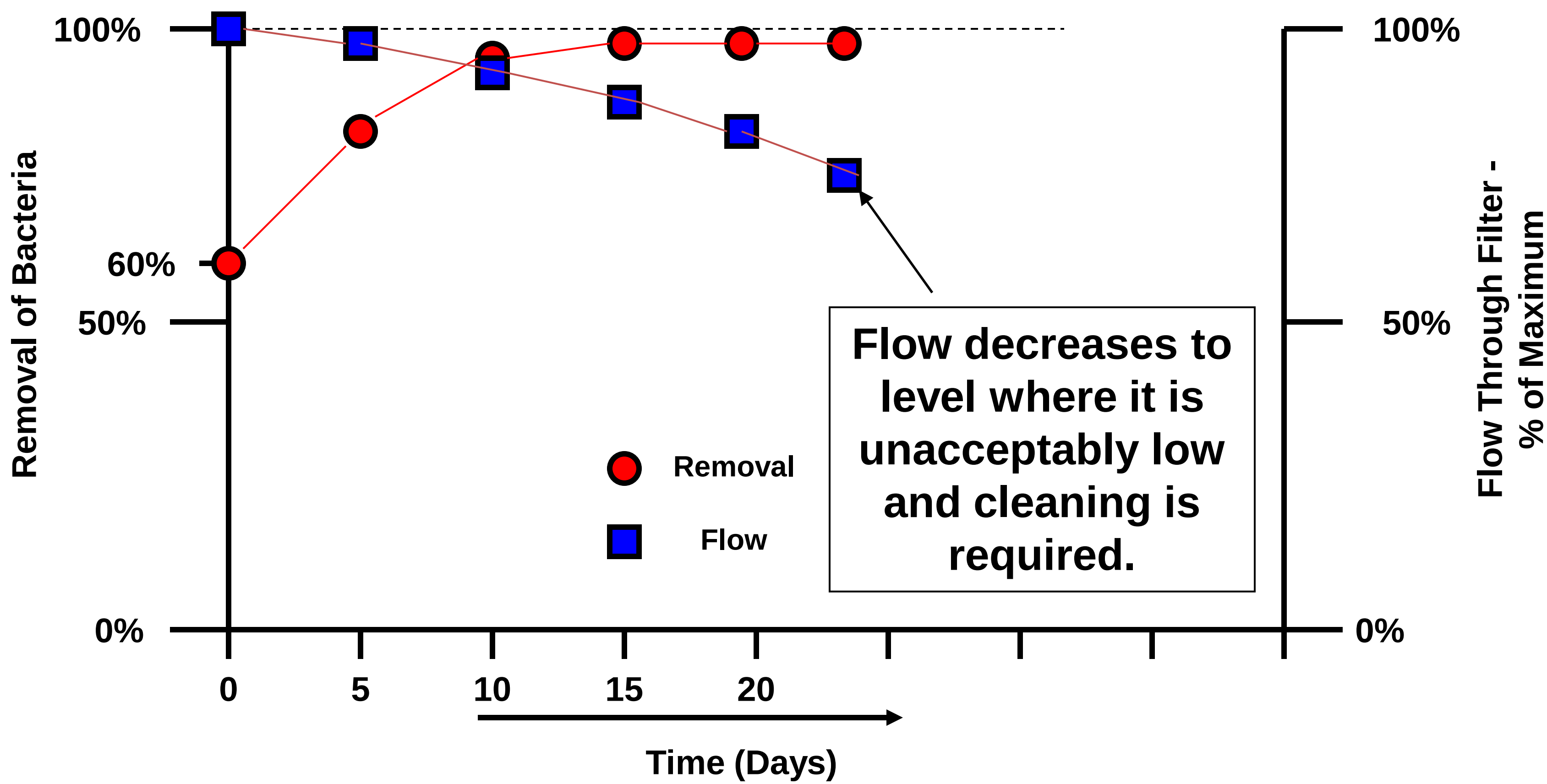


Figure 8. Micrograph of sample removed at week 7 showing a combination of bacteria and diatoms

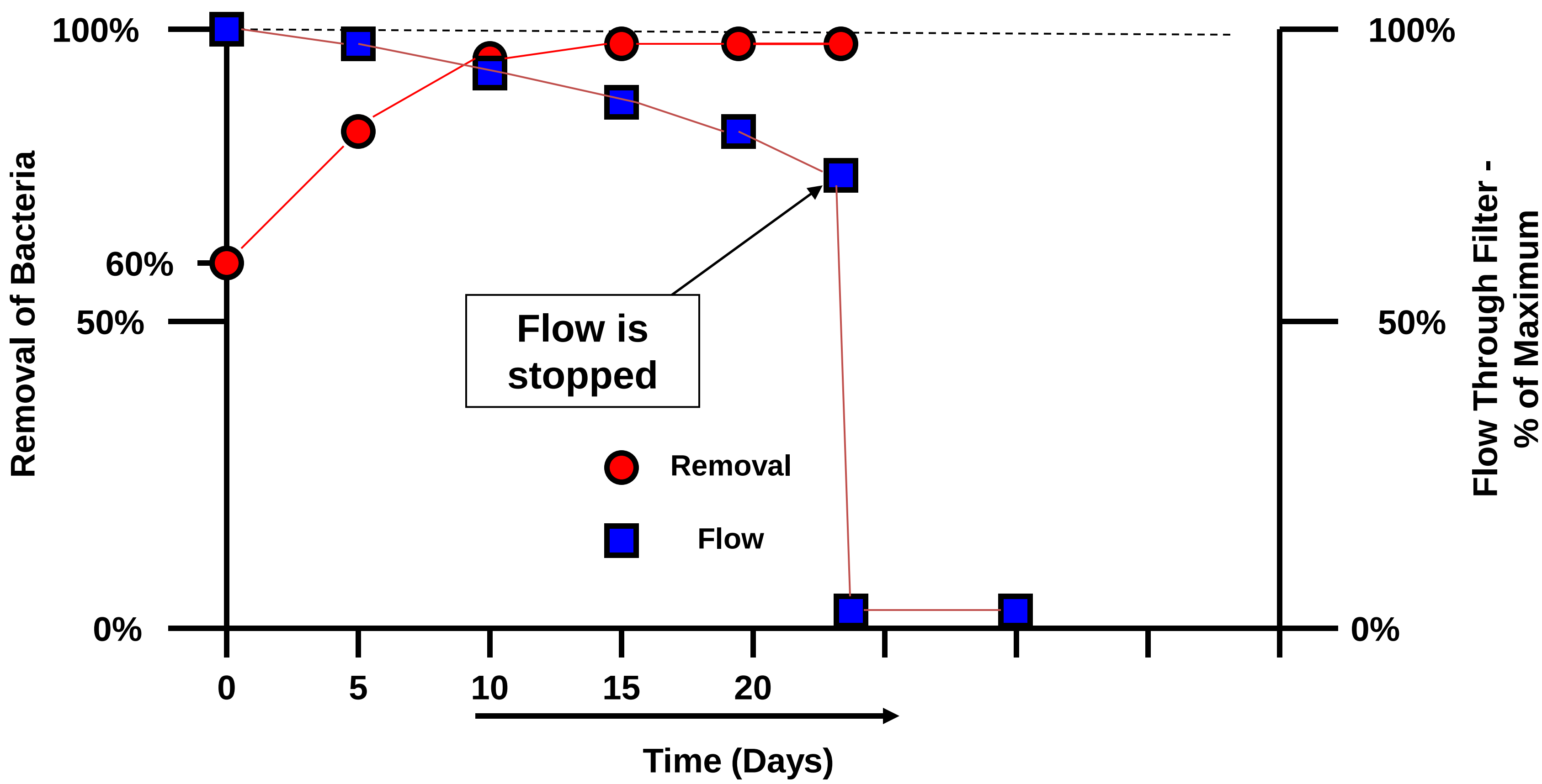
Typical Performance of a Traditional Slow Sand Filter - TSSF



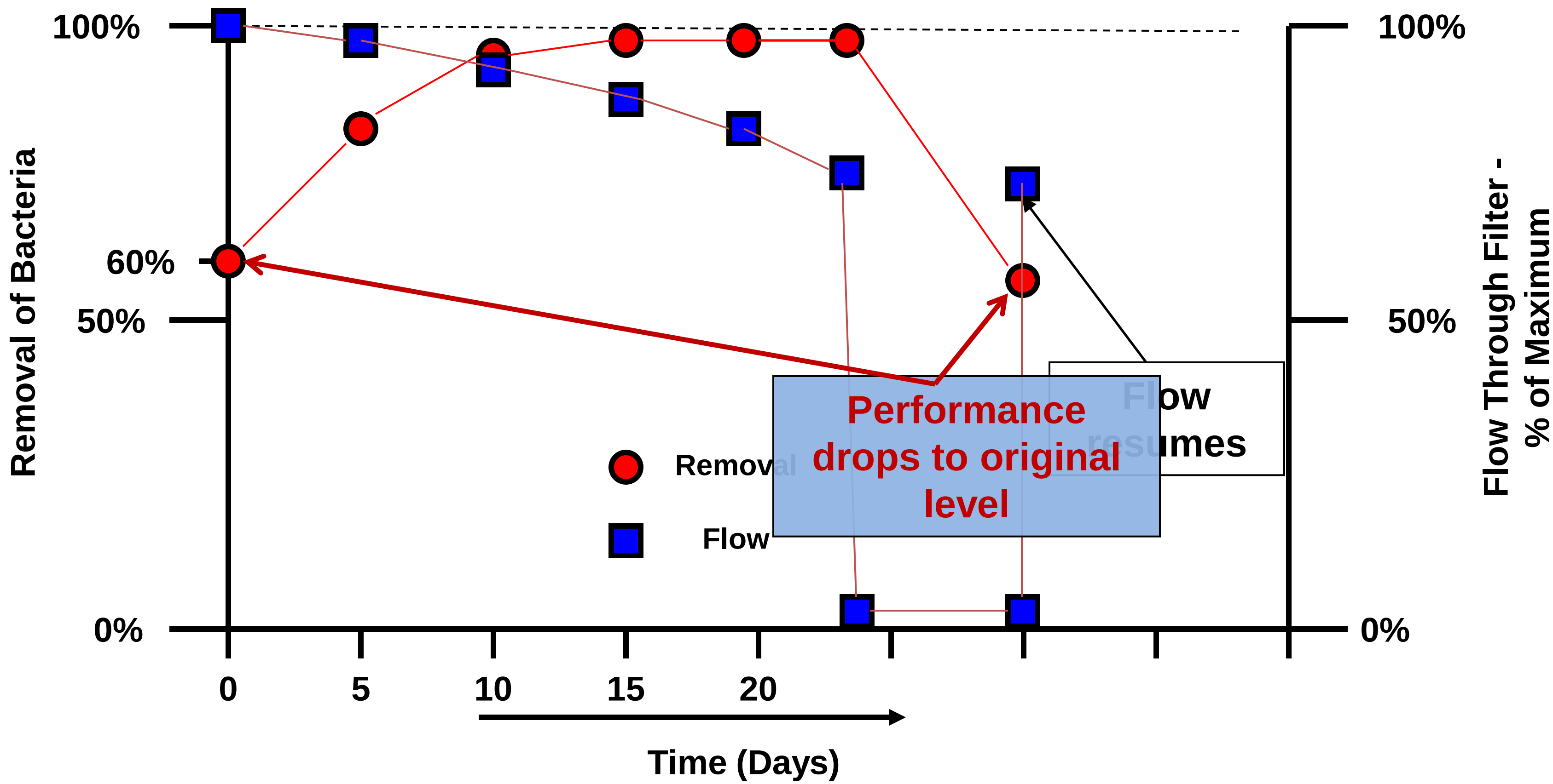
Typical Performance of a Traditional Slow Sand Filter - TSSF



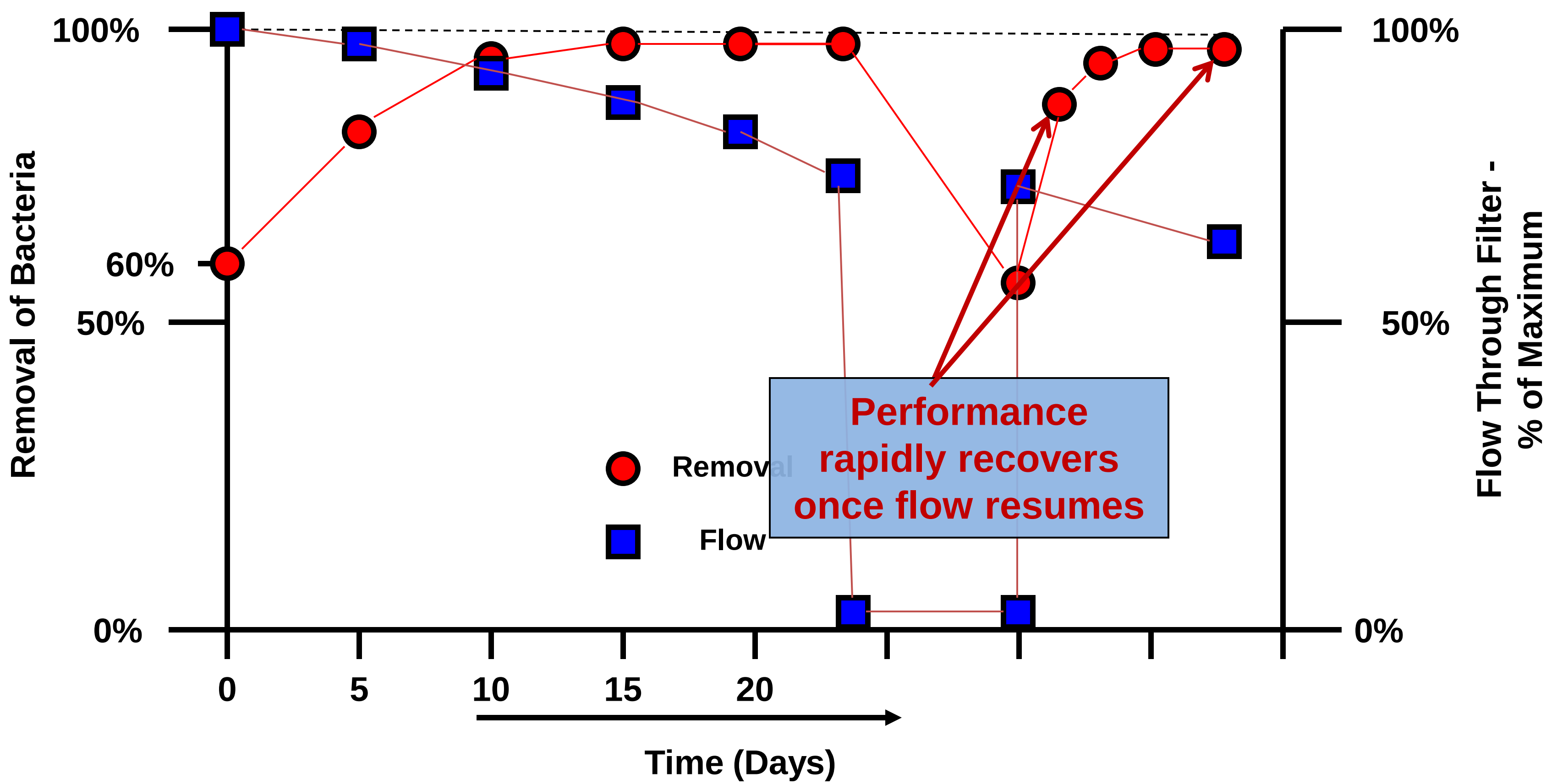
Typical Performance of a TSSF when Flow is Stopped and Resumed



Typical Performance of a TSSF when Flow is Stopped and Resumed



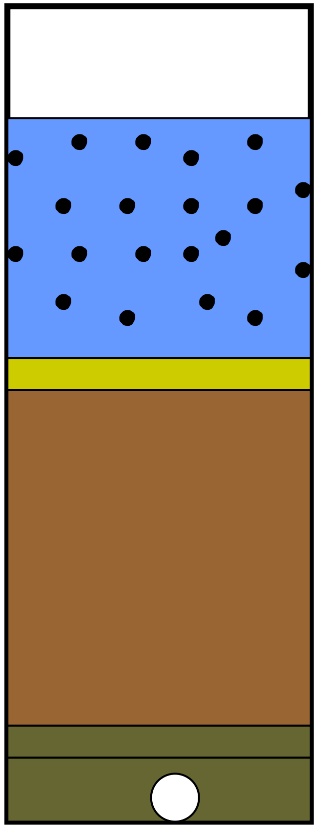
Typical Performance of a TSSF when Flow is Stopped and Resumed



Performance is briefly lost when flow to a TSSF is stopped and started with loss and reformation of biolayer.

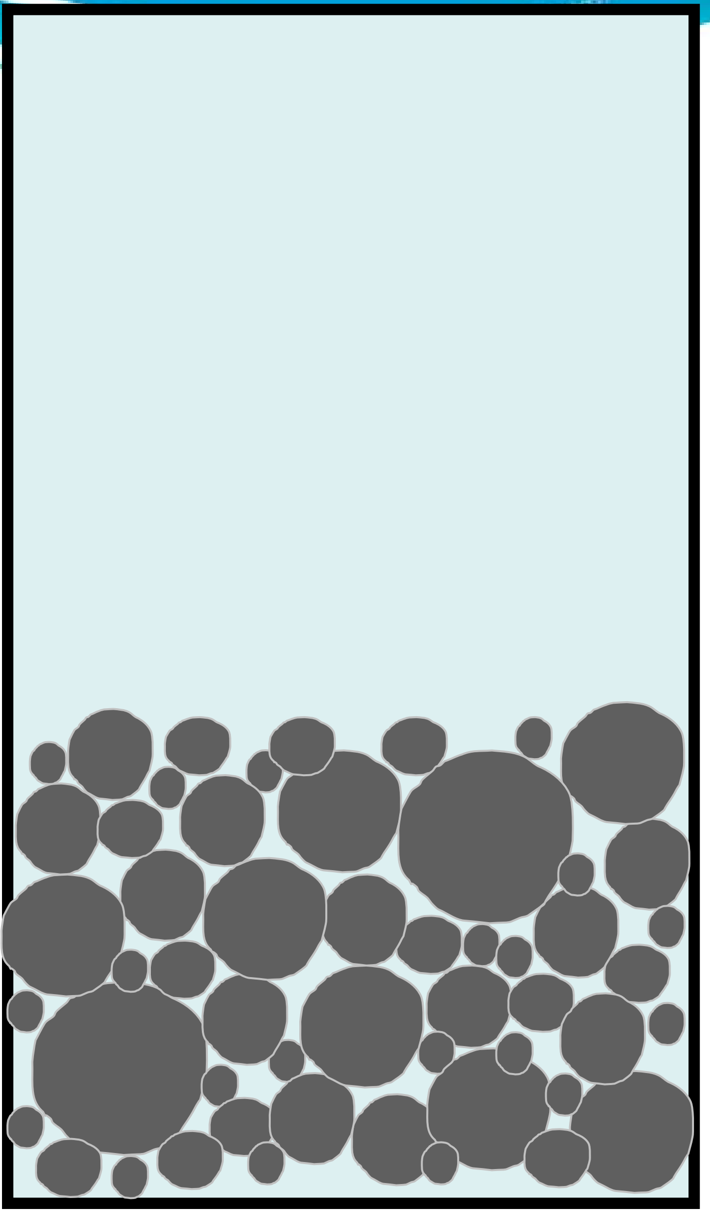
Operation of the MSSF.

Note that an MSSF is backwashed as part of the commissioning process to insure that smallest particles (< 0.1 mm in diameter) are at the filter surface.



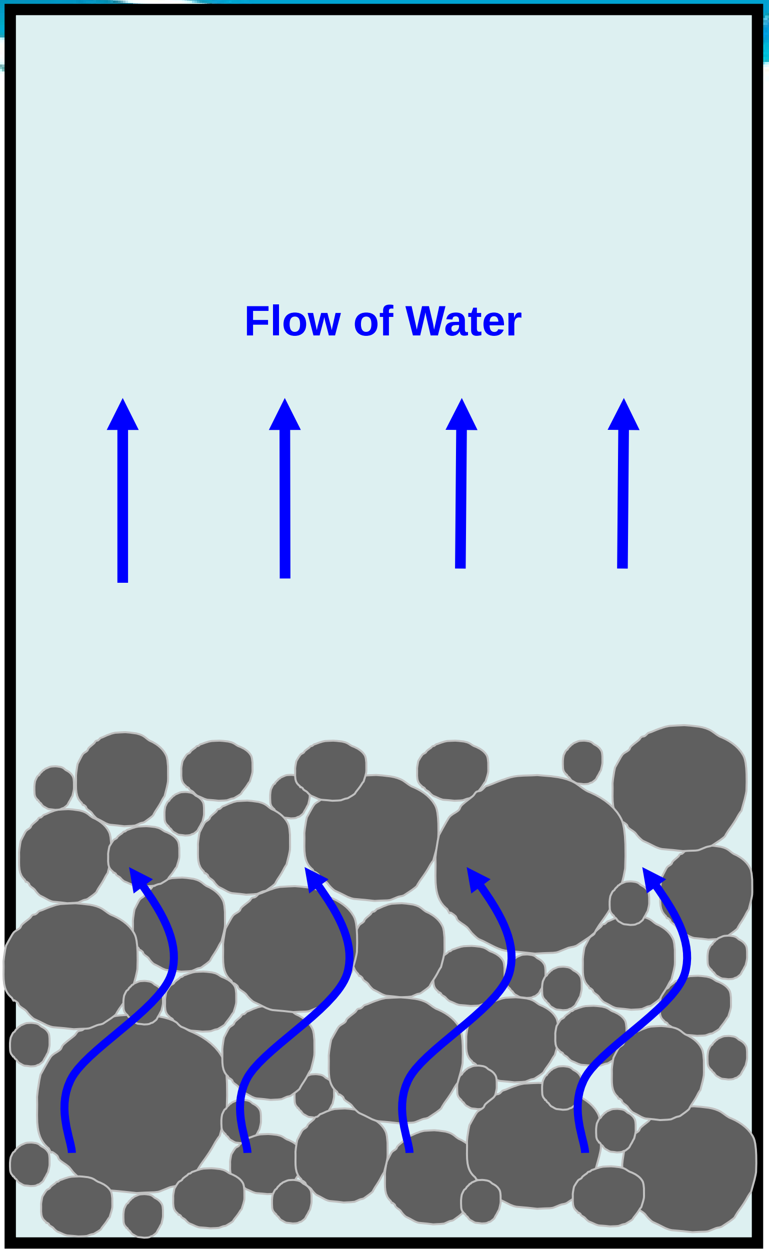
Review of Backwash Process

Consider backwash of typical sand filter when first backwashed:

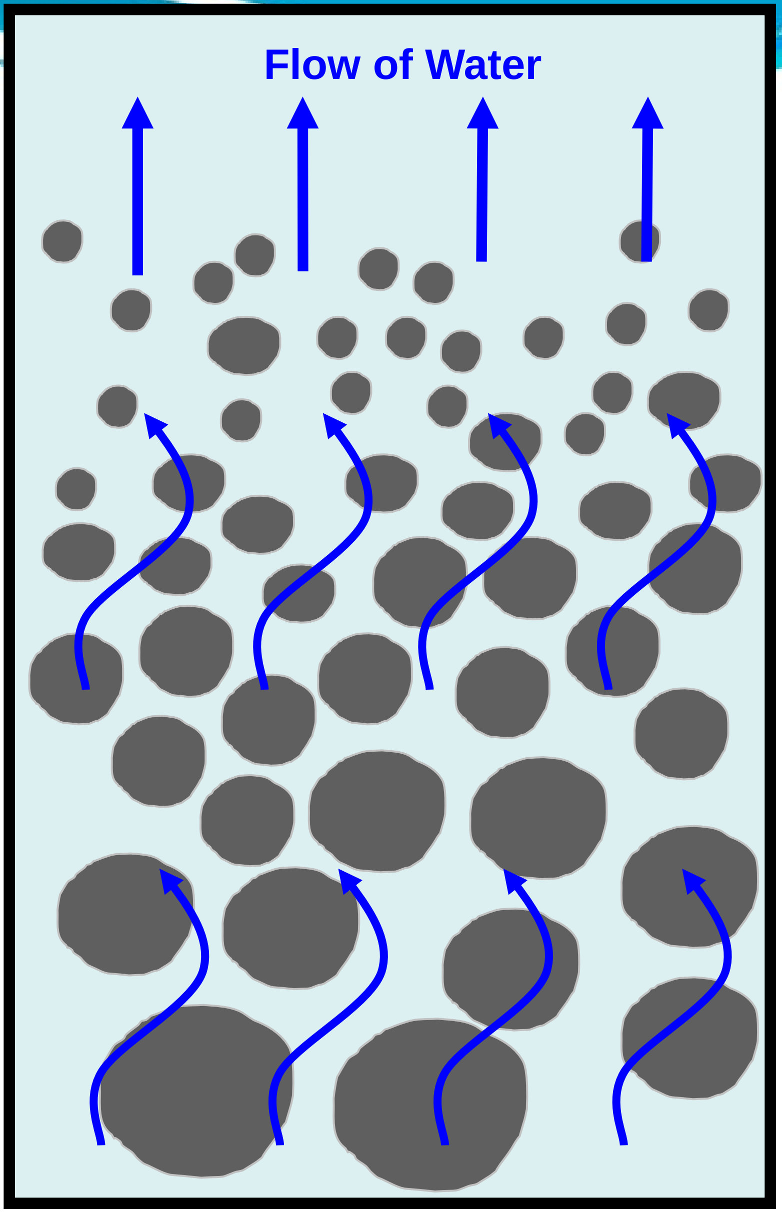


Initially particles having different diameters are mixed together.

Backwash starts.



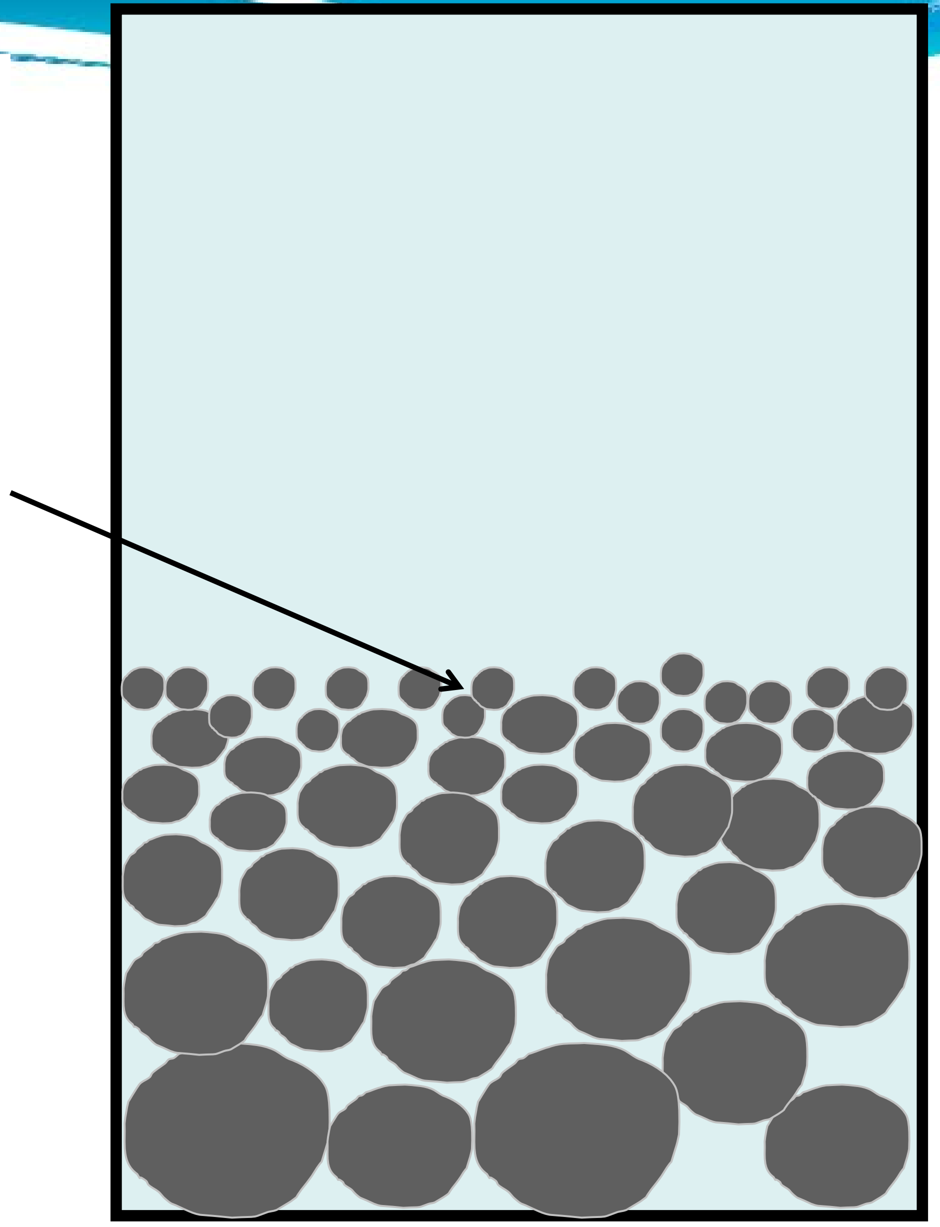
Bed fluidizes.

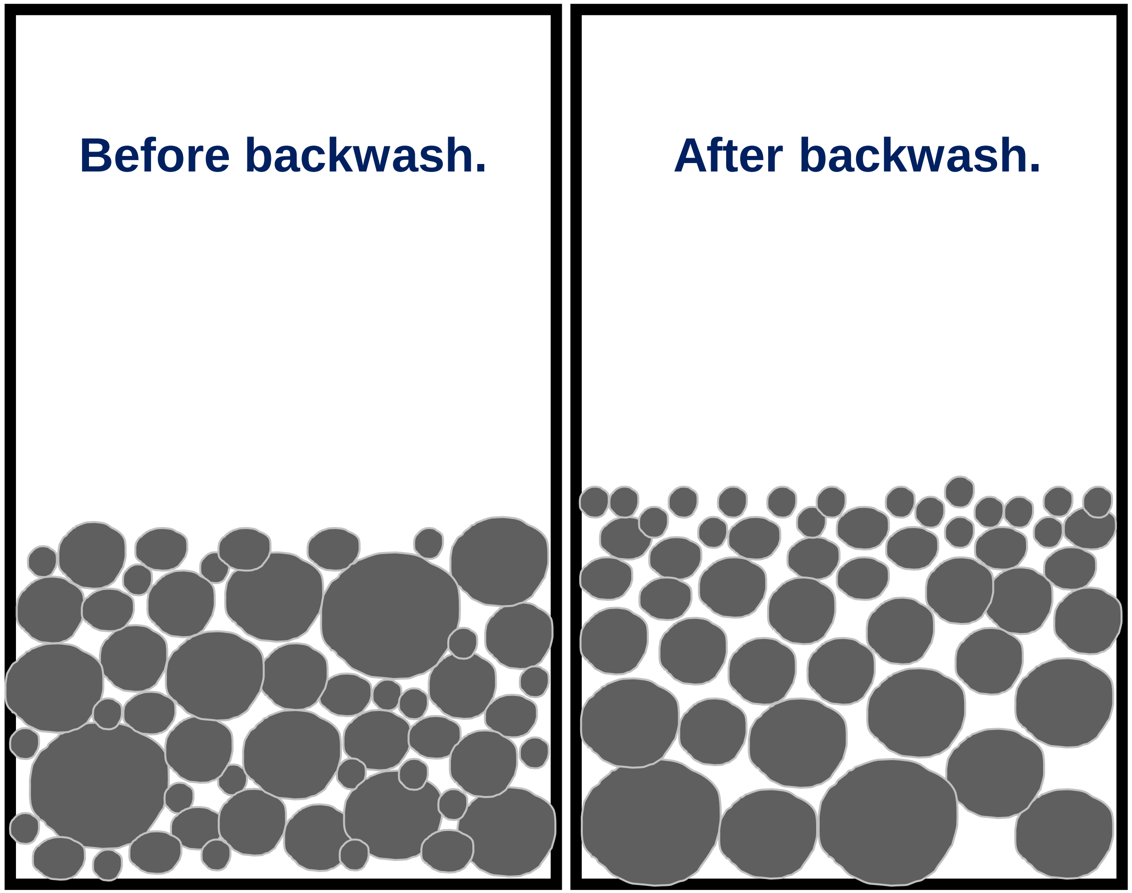


Backwash stops.

The <u>same</u> ‘smallest diameter particles’ will be at the media surface after every backwash.

The backwash of an MSSF is unique in that filter media can never be lost.

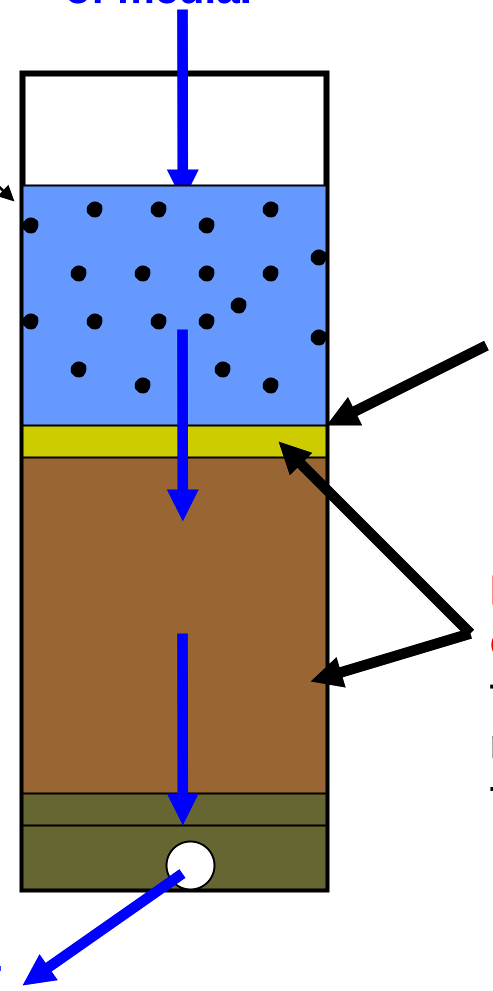



Before backwash.
After backwash.

Operation of the MSSF.

Raw water is added to filter without disturbing surface of media.

Operating water level.



Unlike traditional <u>slow sand filtration</u>, the MSSF can be operated on a **demand basis** when removing micro-organisms.

Similar to traditional <u>slow sand filtration</u>, particulate material is captured on or near surface of the very fine filtering media.

No particulate material is captured within media because the water is not <u>forced</u> into the media as it is in rapid sand filtration or pressure filtration.

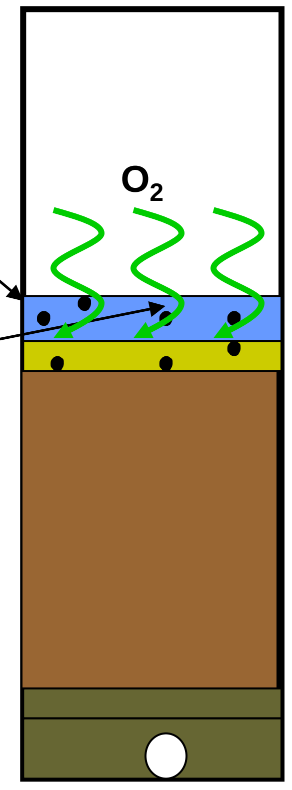
Filtered water exits filter.

Operation of the MSSF when flow is stopped.

Flow to filter is stopped.

Water level drains to paused or minimum depth – minimum 5cm.

Sufficient oxygen can diffuse through the shallow layer of water to keep aerobic biolayer alive.



Note: Paused depth should NOT be less than 5 cm as the biolayer will be disturbed when water is added. Paused depths much greater than 5 cm may limit transfer of oxygen to the biolayer impairing its performance. 5 cm is considered the optimum.

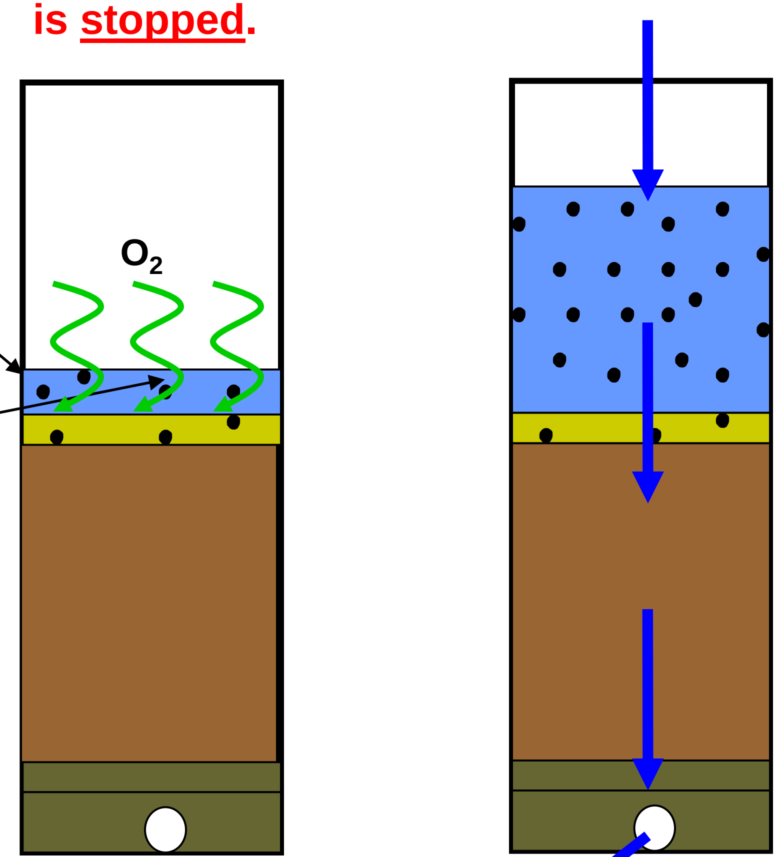
Operation of the MSSF when flow is resumed.

Flow to filter is stopped.

Flow to filter resumes.

Water level drains to paused or minimum depth – minimum 5cm.

Sufficient oxygen can diffuse through the shallow layer of water to keep aerobic biolayer alive.

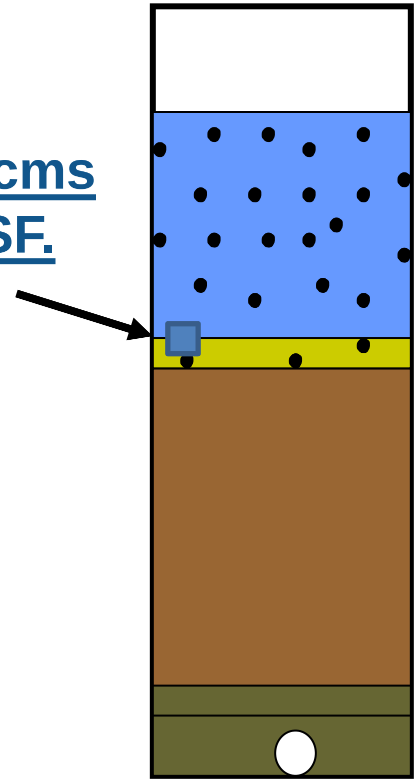


Mature healthy biolayer is still present.

Filtered water exits filter.

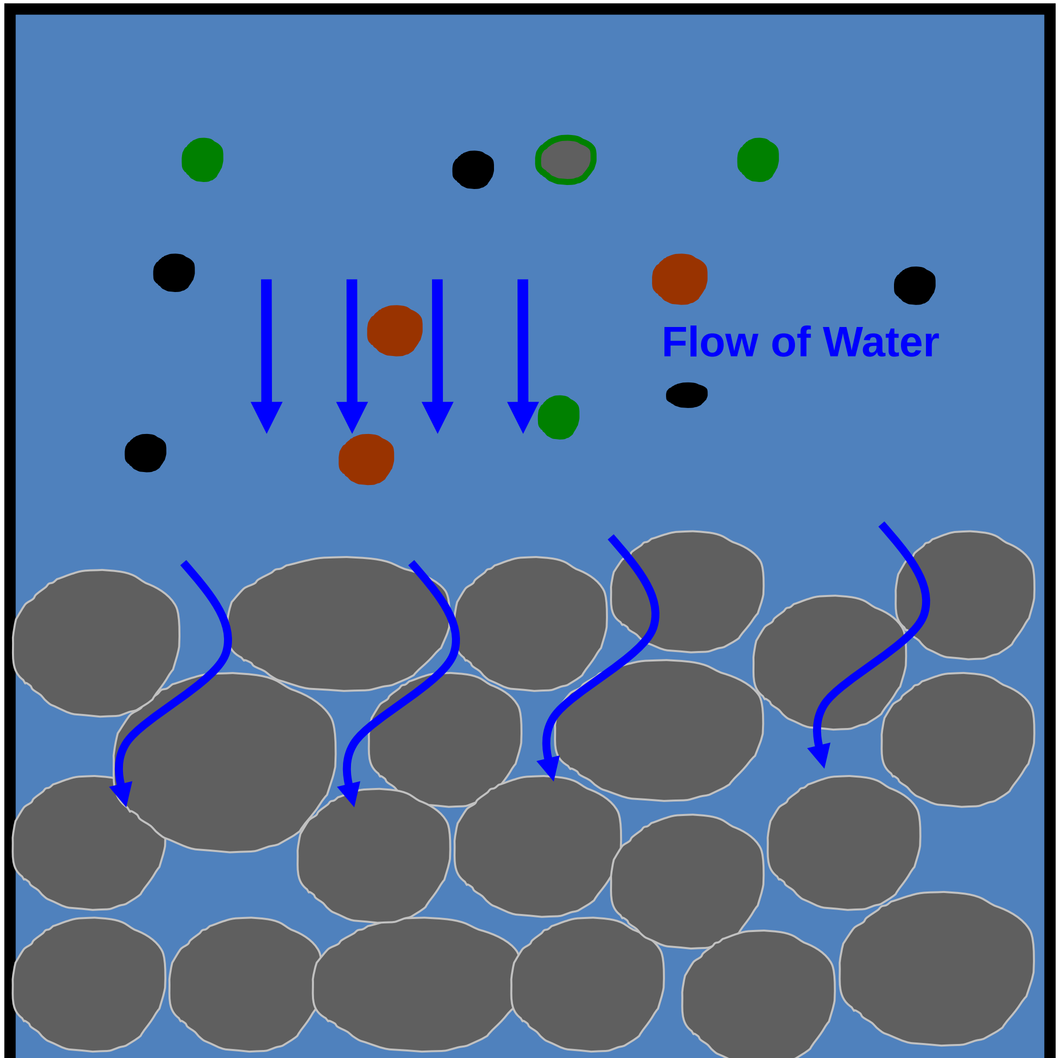
Note: Paused depth should NOT be less than 5 cm as the biolayer will be disturbed when water is added. Paused depths much greater than 5 cm may limit transfer of oxygen to the biolayer impairing its performance. 5 cm is considered the optimum.

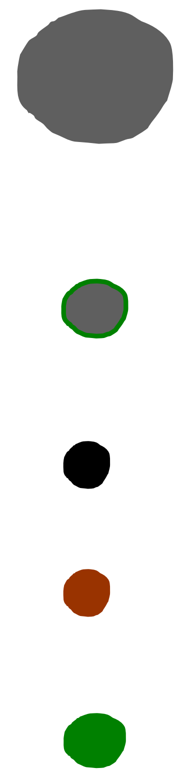
Examine the Top 1 - 2 cms of the media in an MSSF.



Operation of MSSF.

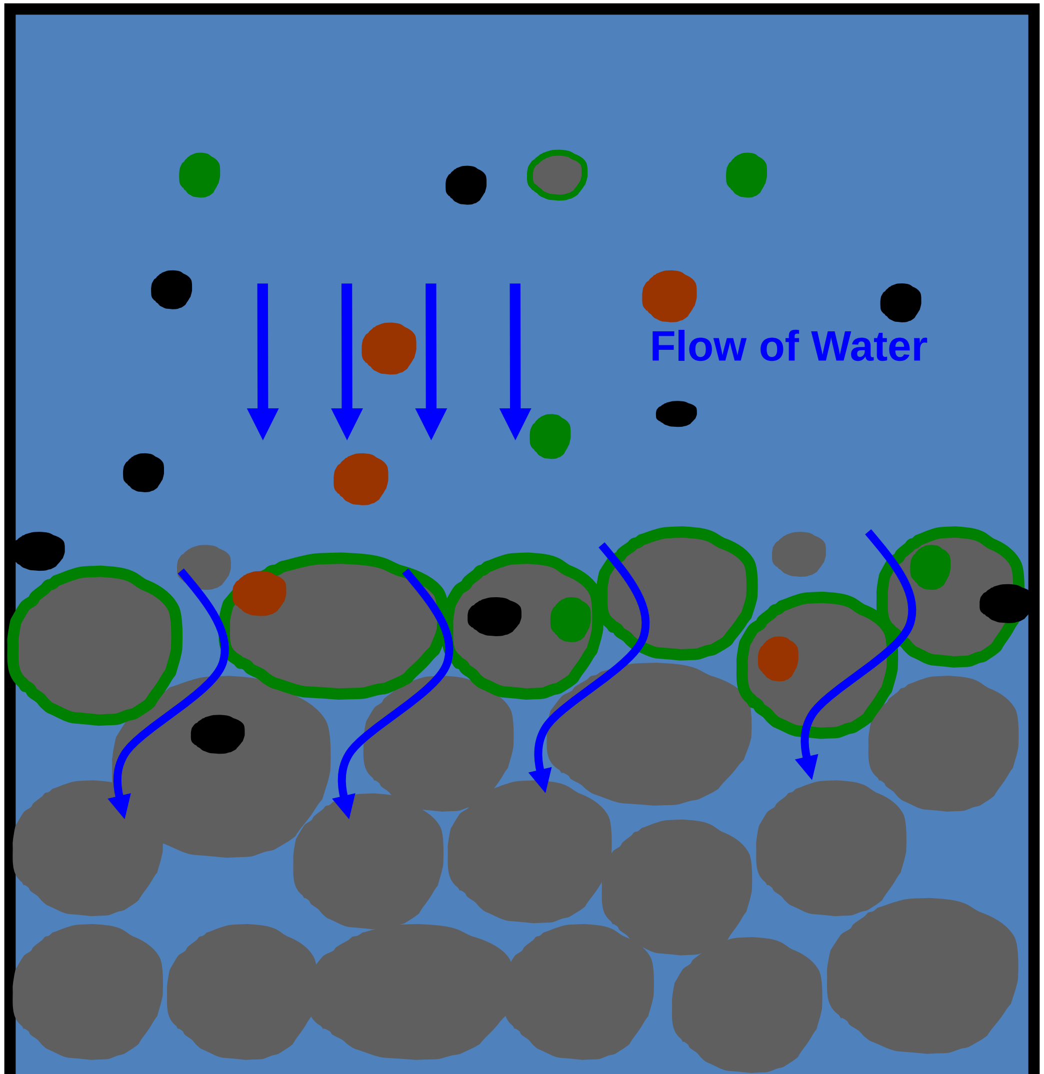
Beginning of operation of the MSSF – no biofilm around particles and no biolayer.



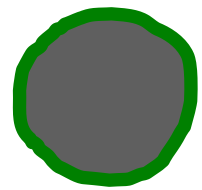


Operation of MSSF.

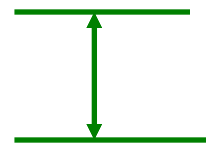
Beginning of operation of the MSSF



No biolayer is necessary for removal of parasites and larger organic material and mineral particles including oxidized iron and manganese.



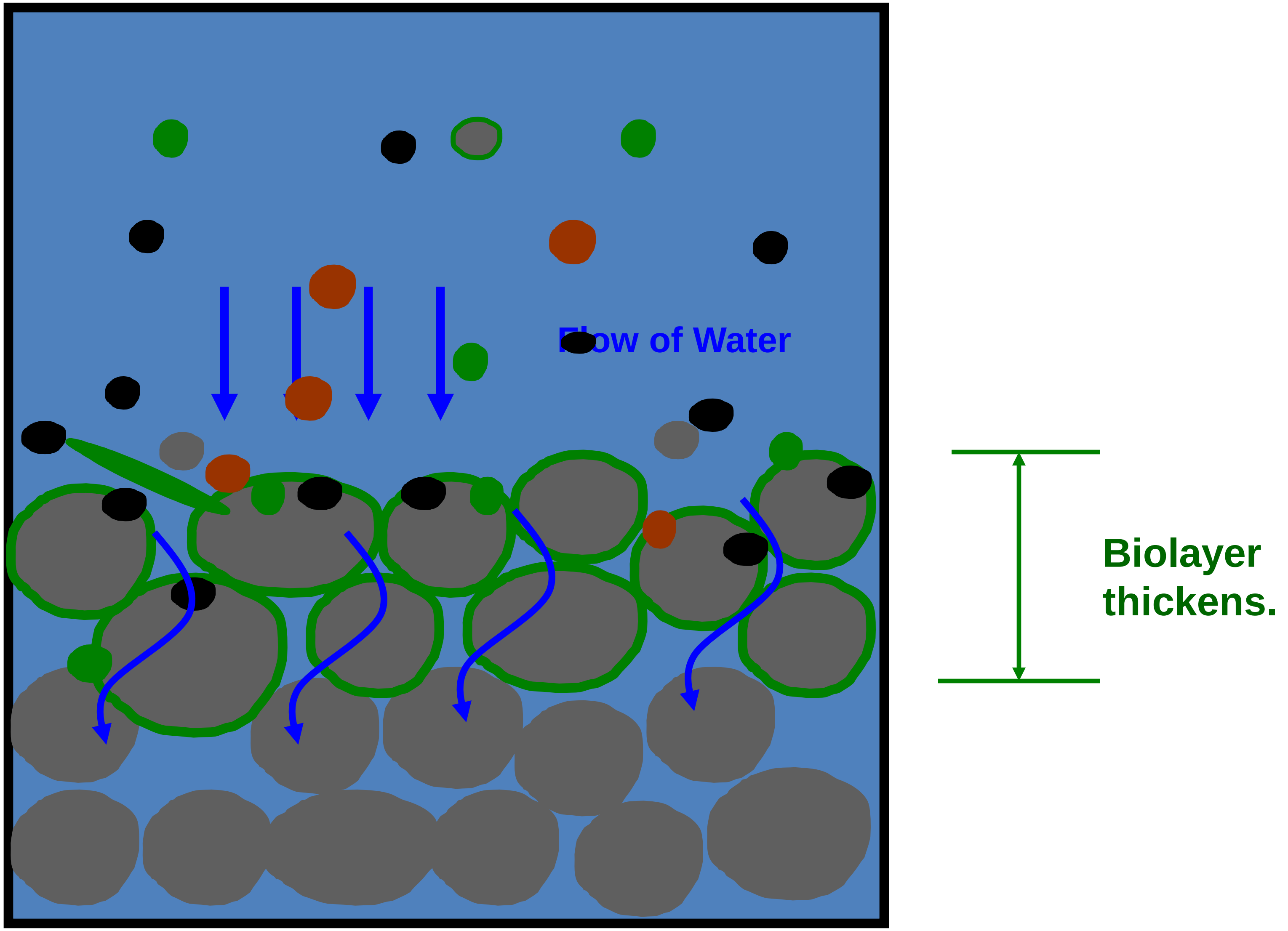
Media particle covered with a surface biofilm including bacteria and organic matter.



Biolayer (Mineral particles covered with a biofilm).

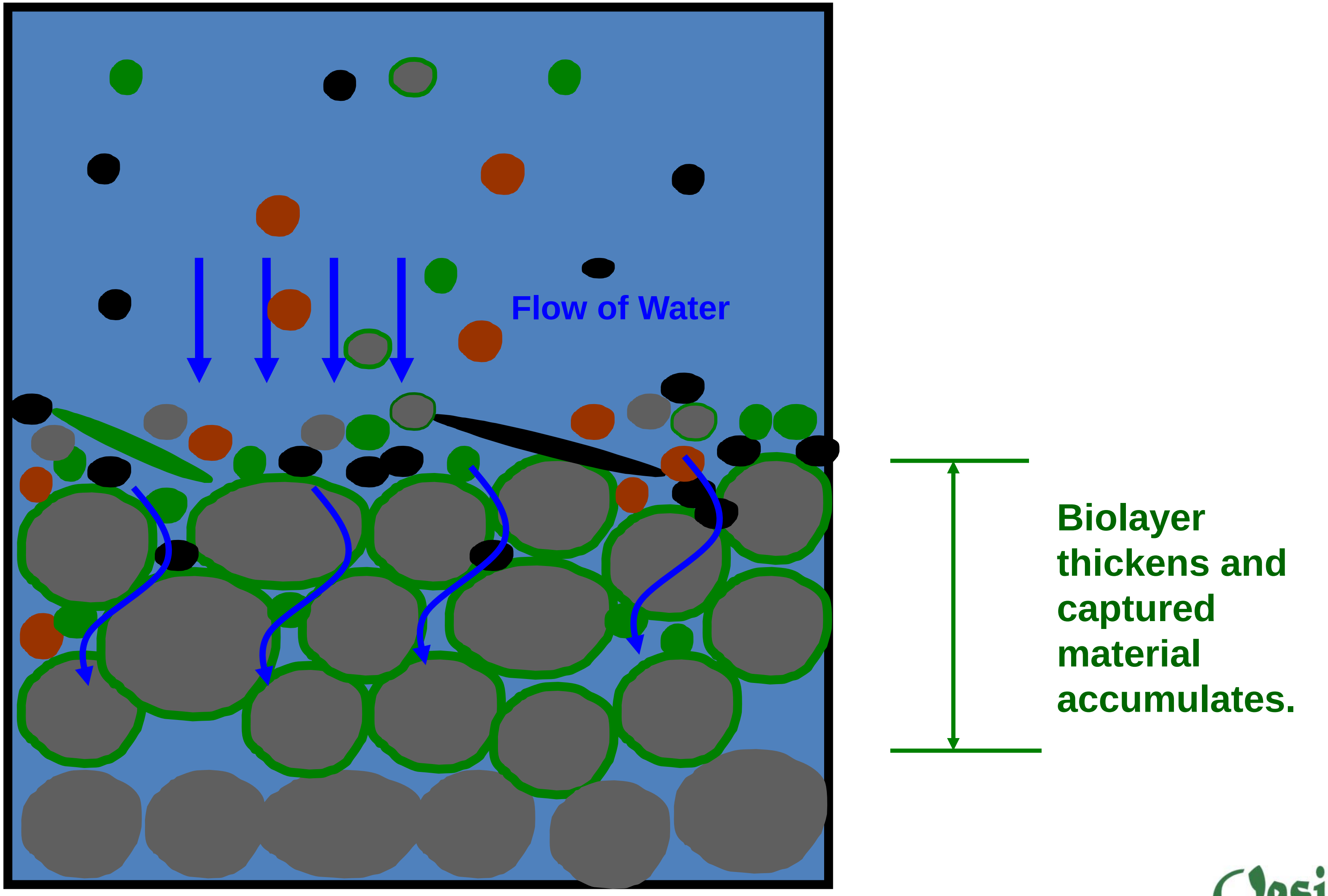
Operation of MSSF.

Biolayer thickens with use and time.



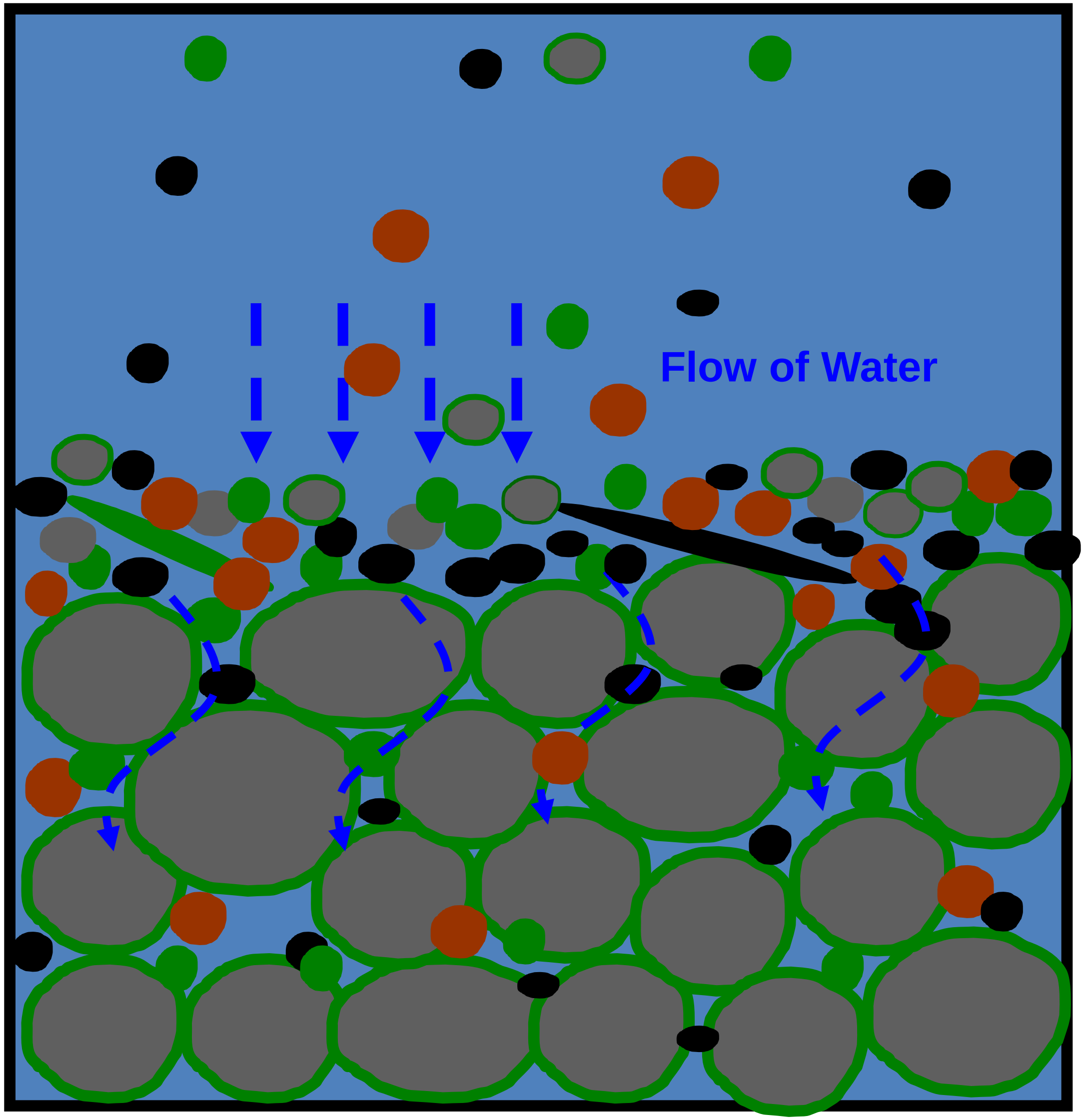
Operation of MSSF.

Biolayer thickens with use and time.



Operation of MSSF.

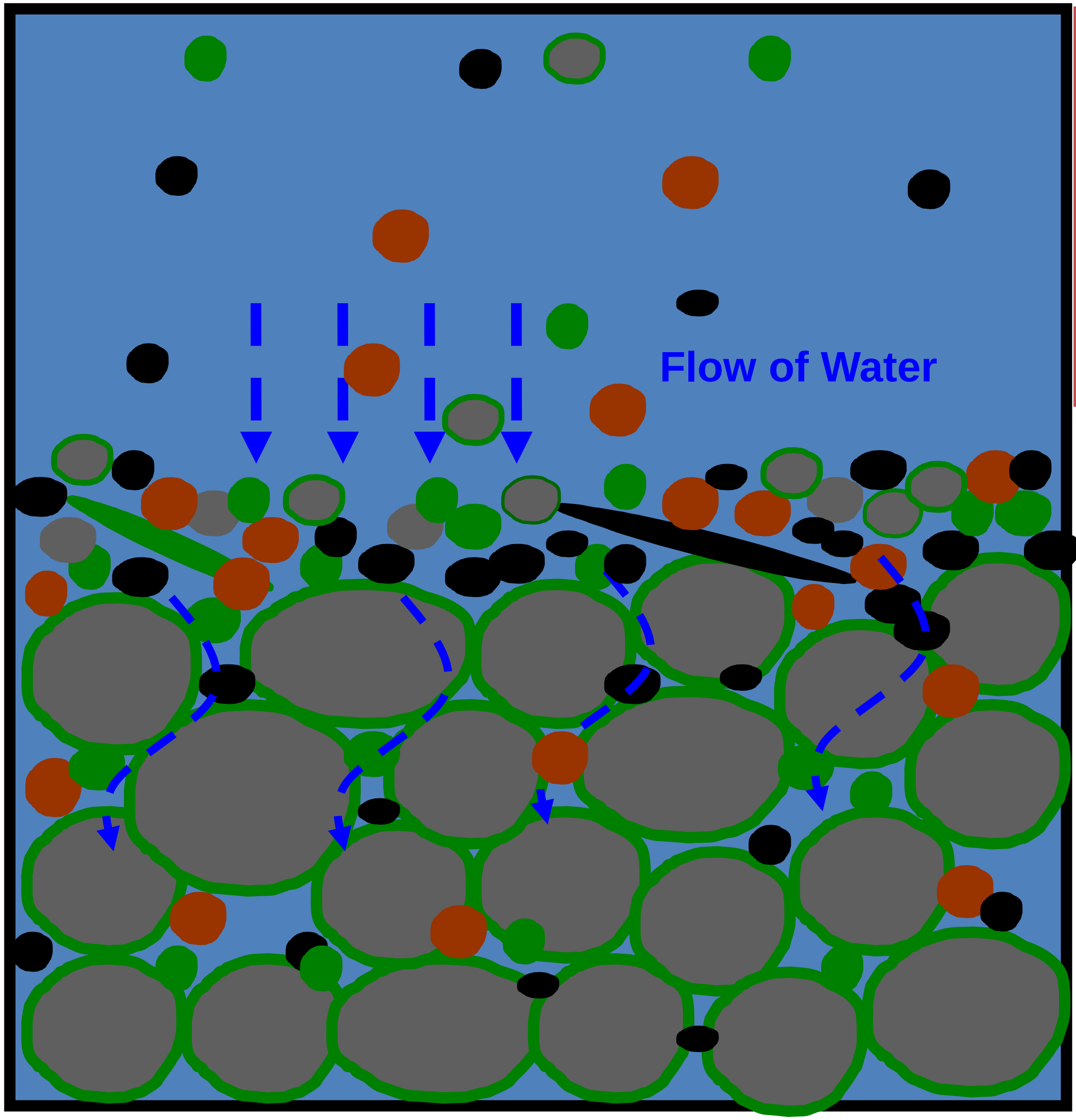
Biolayer thickens with use and time.



Biolayer thickens and captured material accumulates and starts to restrict flow.

Operation of MSSF.

Biolayer thickens with use and time.

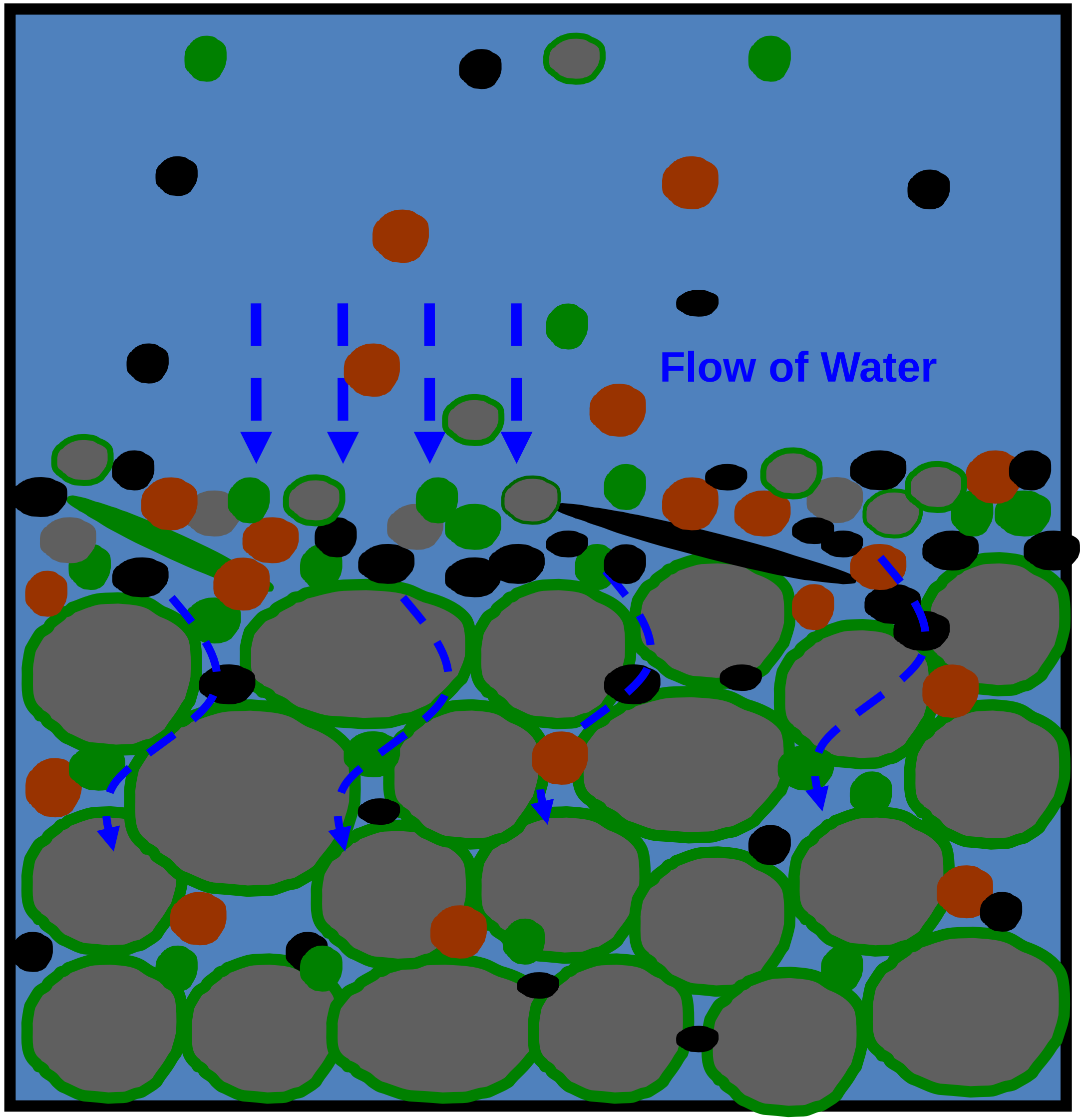


Formation of biolayer will depend on the ecology of the water being treated and the quantity of water being treated. The greater the concentration of aquatic life and the greater the quantity of water being treated the faster the biolayer will form.

Biolayer thickens and captured material accumulates and starts to restrict flow.

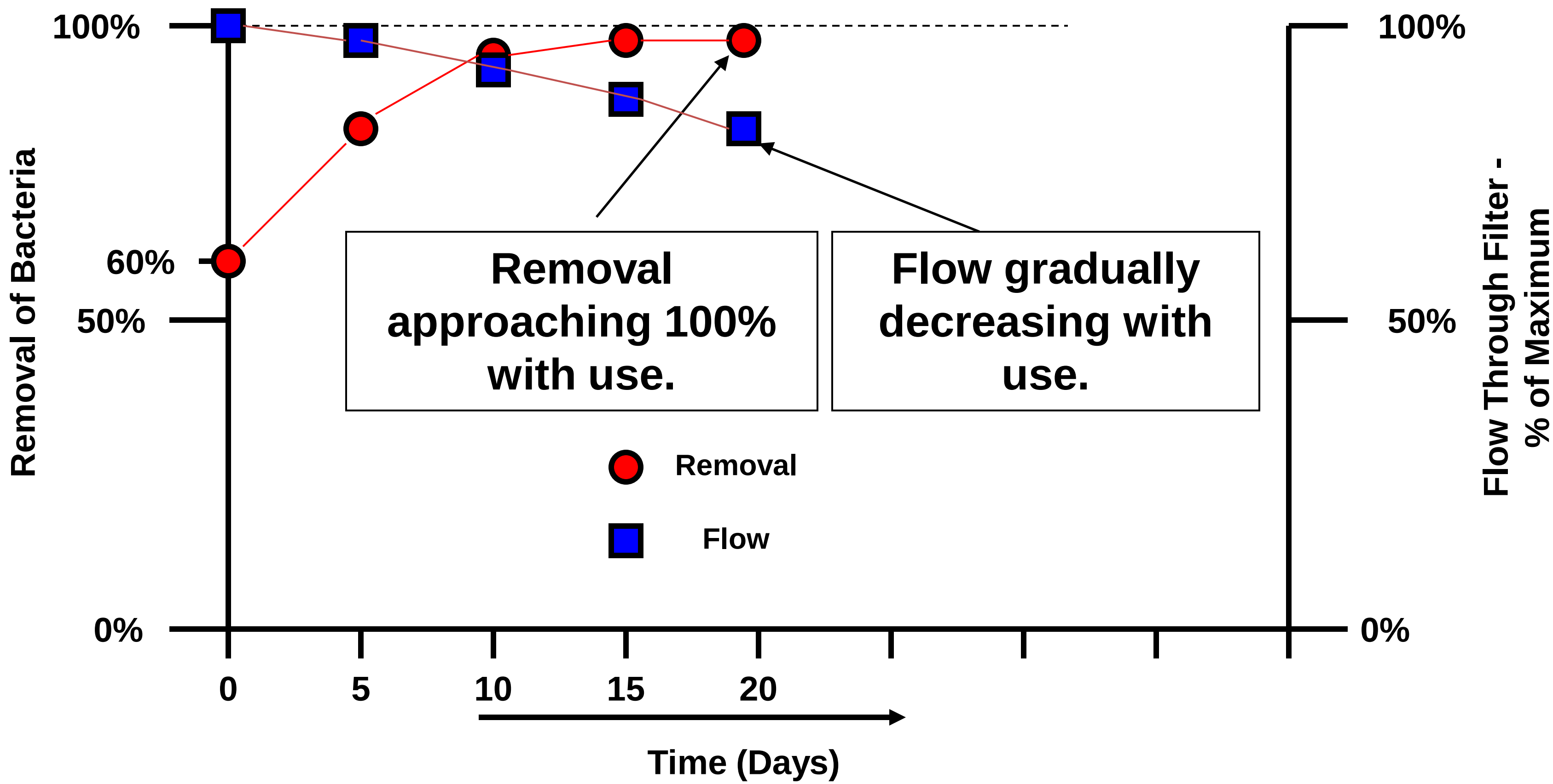
Operation of MSSF.

Flow is unacceptably low and surface layer must be cleaned.

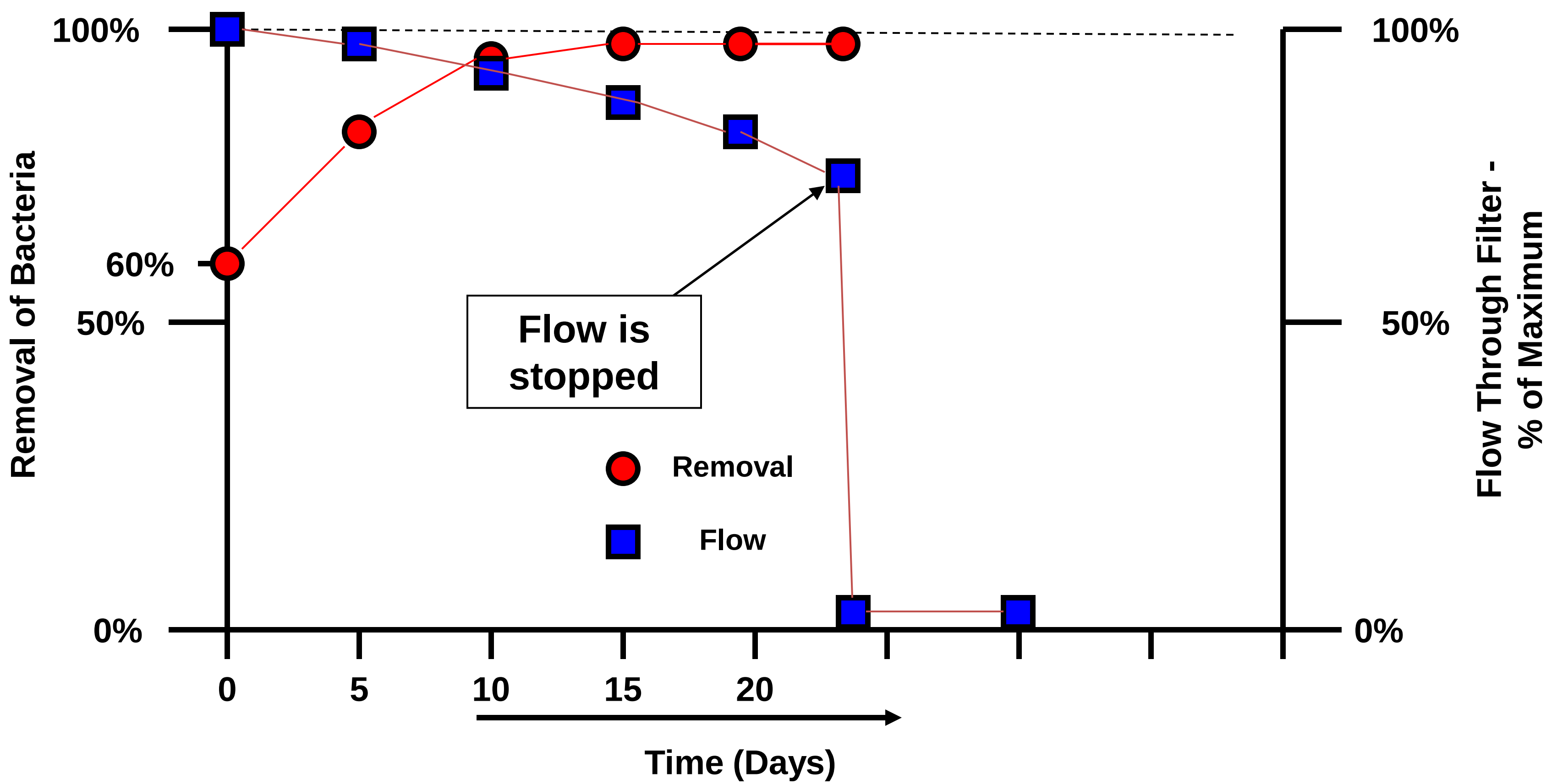


Cleaning the MSSF will leave biolayer intact.

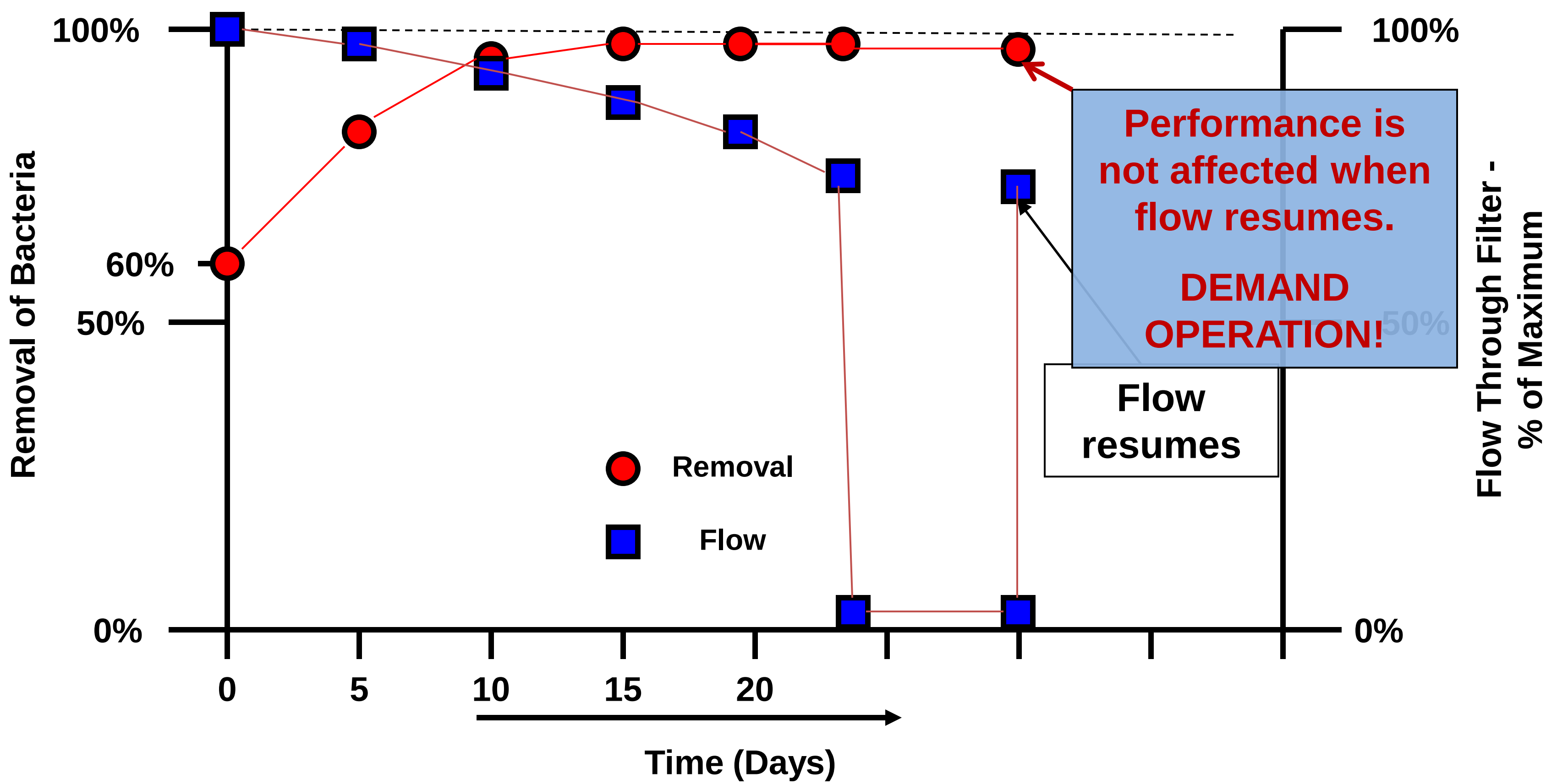
Typical Performance of a MSSF Water Filtration Technology



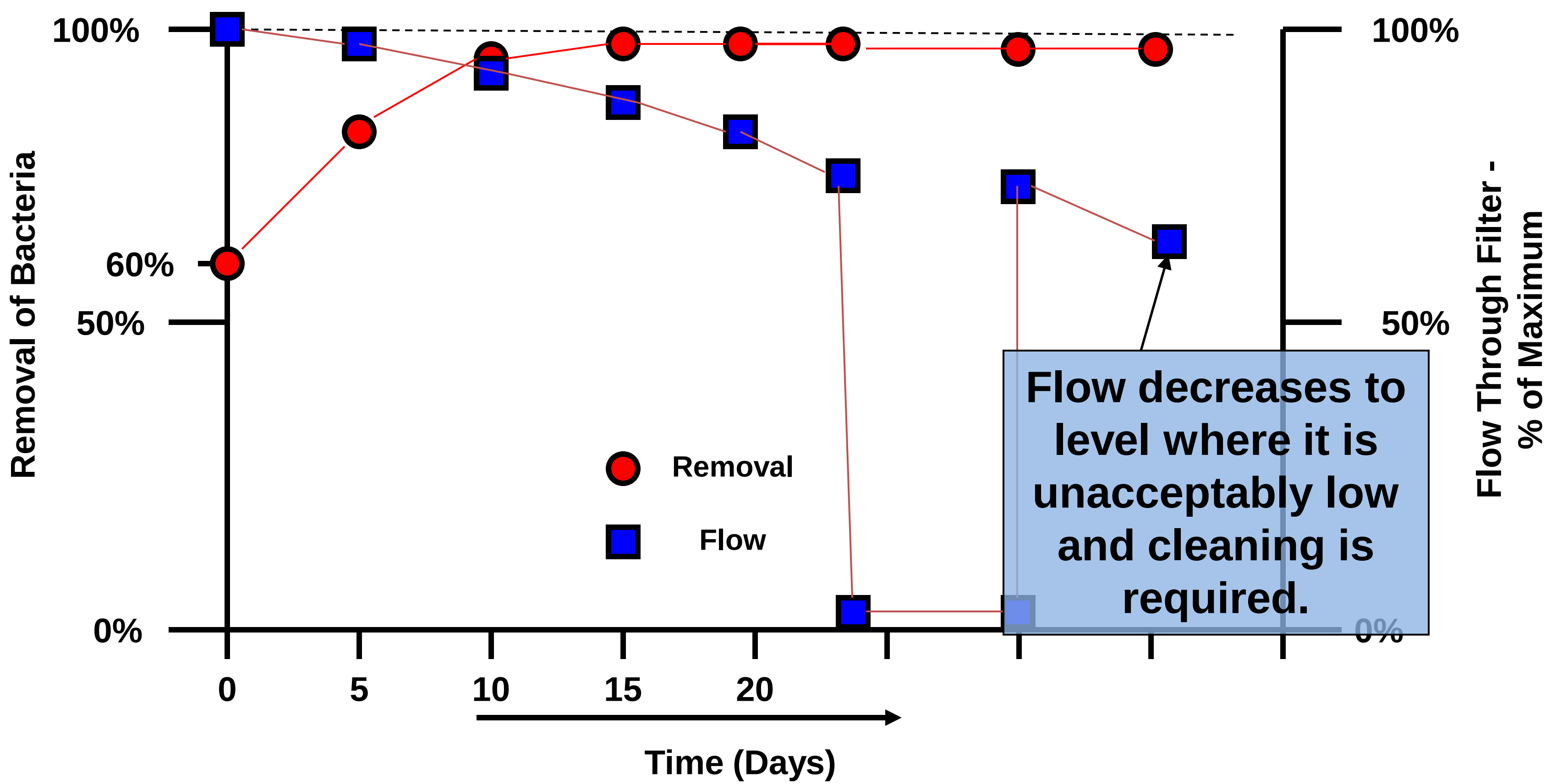
MSSF is Stopped (Normal Operation)



MSSF Resumes (Normal Operation)



MSSF Resumes (Normal Operation)



TSSF and MSSF have similar performance when the TSSF is operated continuously and the MSSF is operated continuously or intermittently.

Comparison of Cleaning of TSSF and MSSF technologies

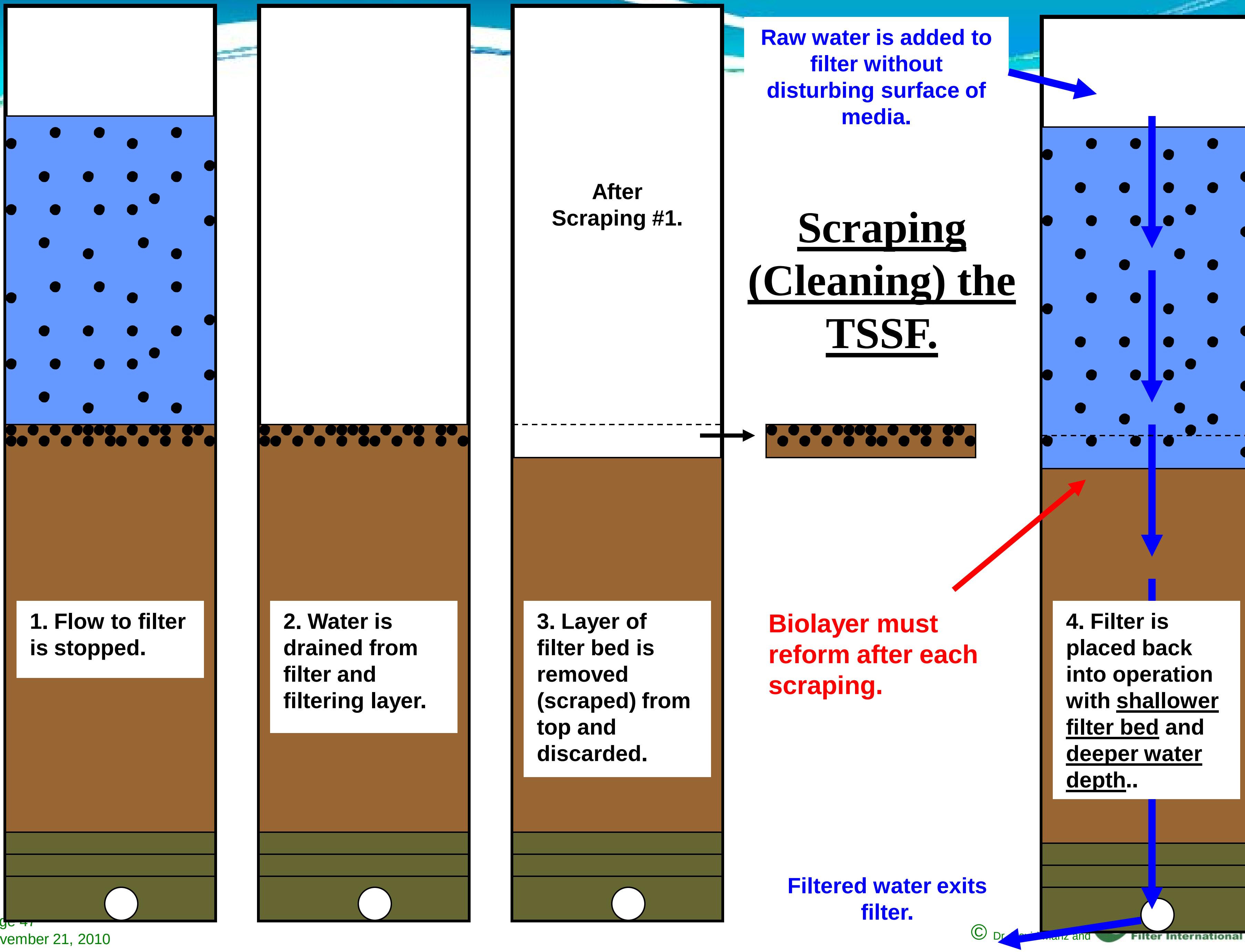
Normal Cleaning of TSSF.

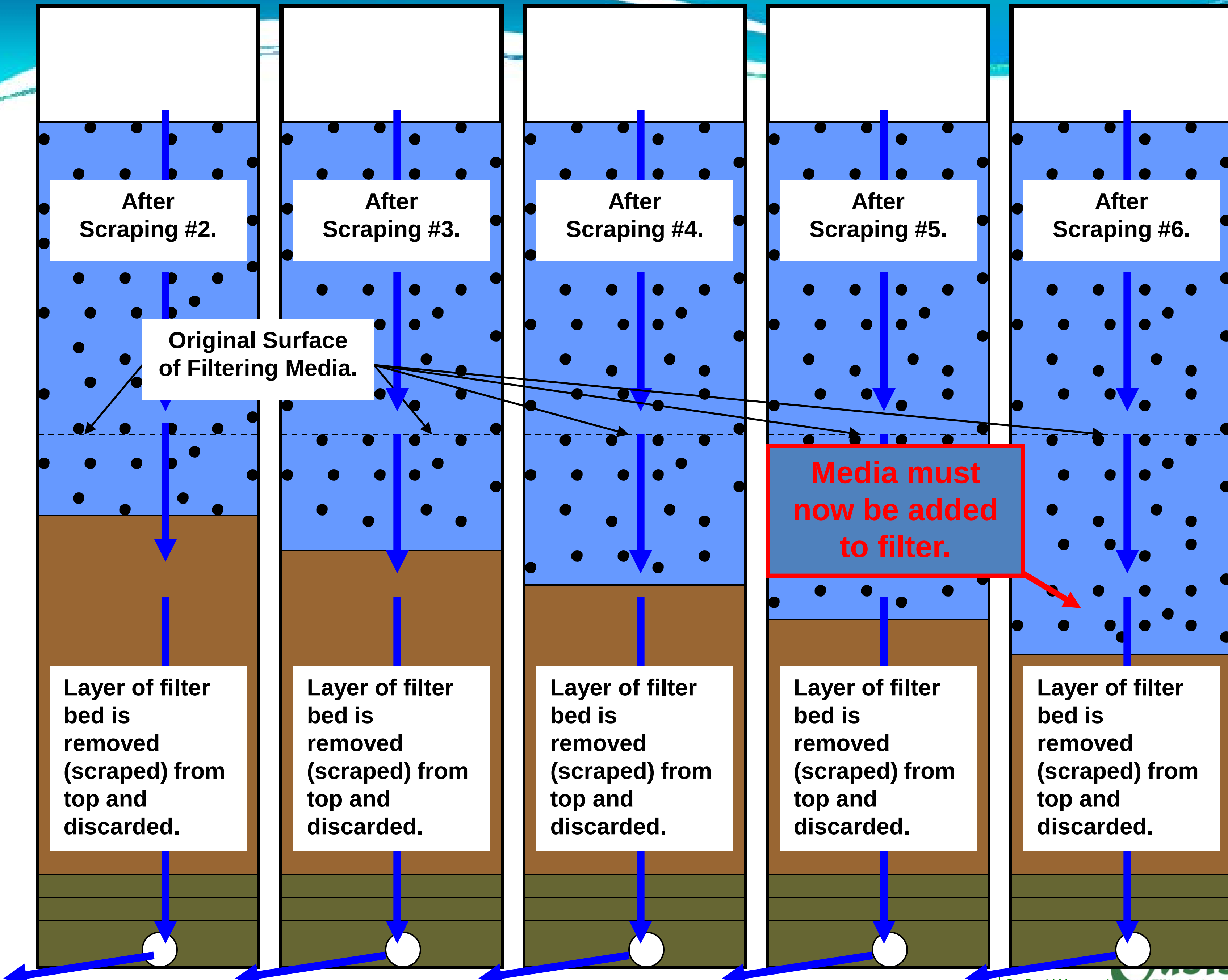
1. **Filter is drained.**
2. **Up to 5 cm of media (including biolayer) is removed and discarded.**
3. **Filter is placed into operation. Biolayer will take several days to reform.**

Entire cleaning process can take <u>several hours</u> to <u>days</u> to perform depending on size of filter.

Ultimately new media will be added to filter.

Scraping (Cleaning) the TSSF.




After Scraping #2.
After Scraping #3.
After Scraping #4.
After Scraping #5.
After Scraping #6.
Original Surface of Filtering Media.
Media must now be added to filter.
Layer of filter bed is removed (scraped) from top and discarded.
Layer of filter bed is removed (scraped) from top and discarded.
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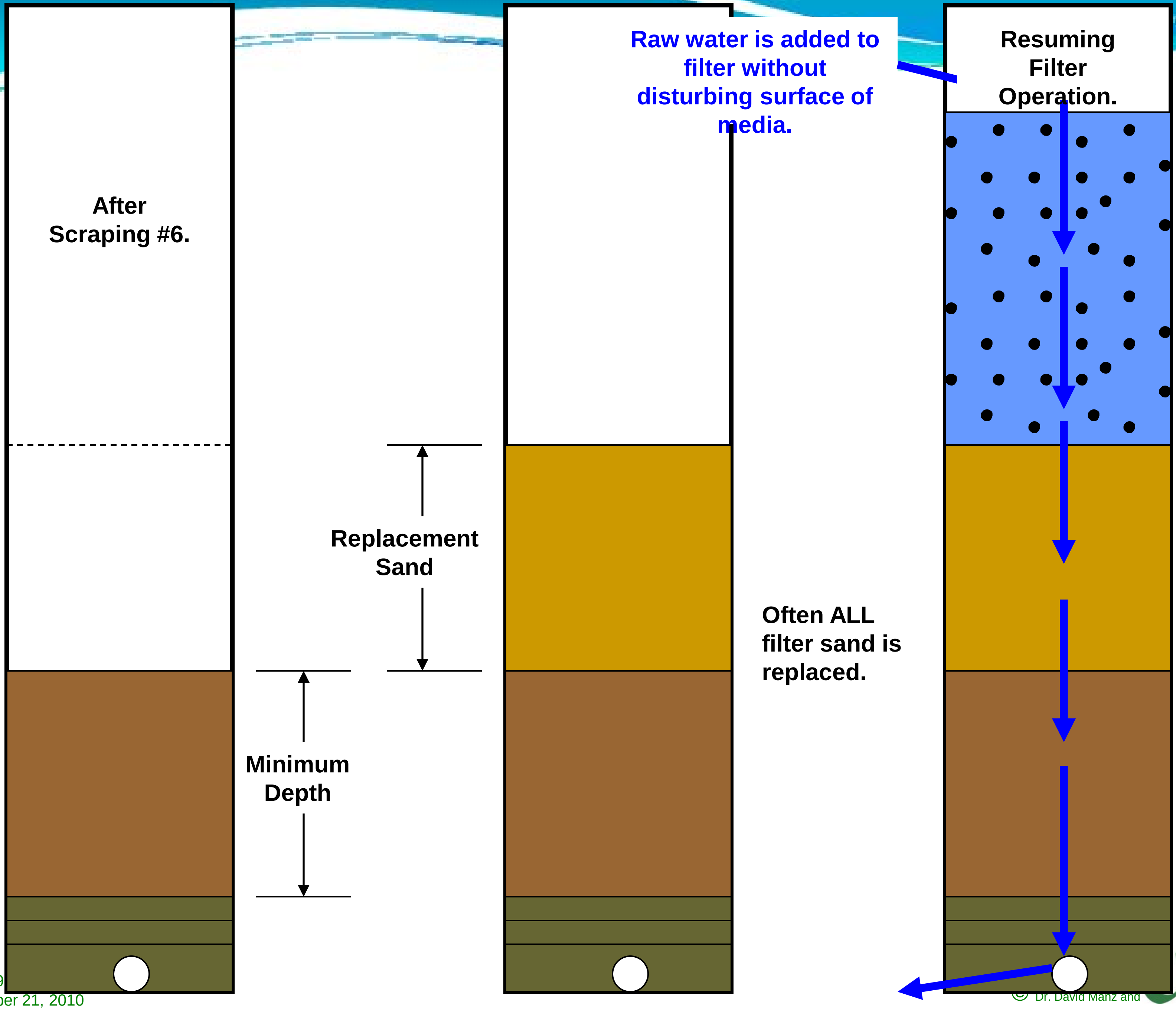
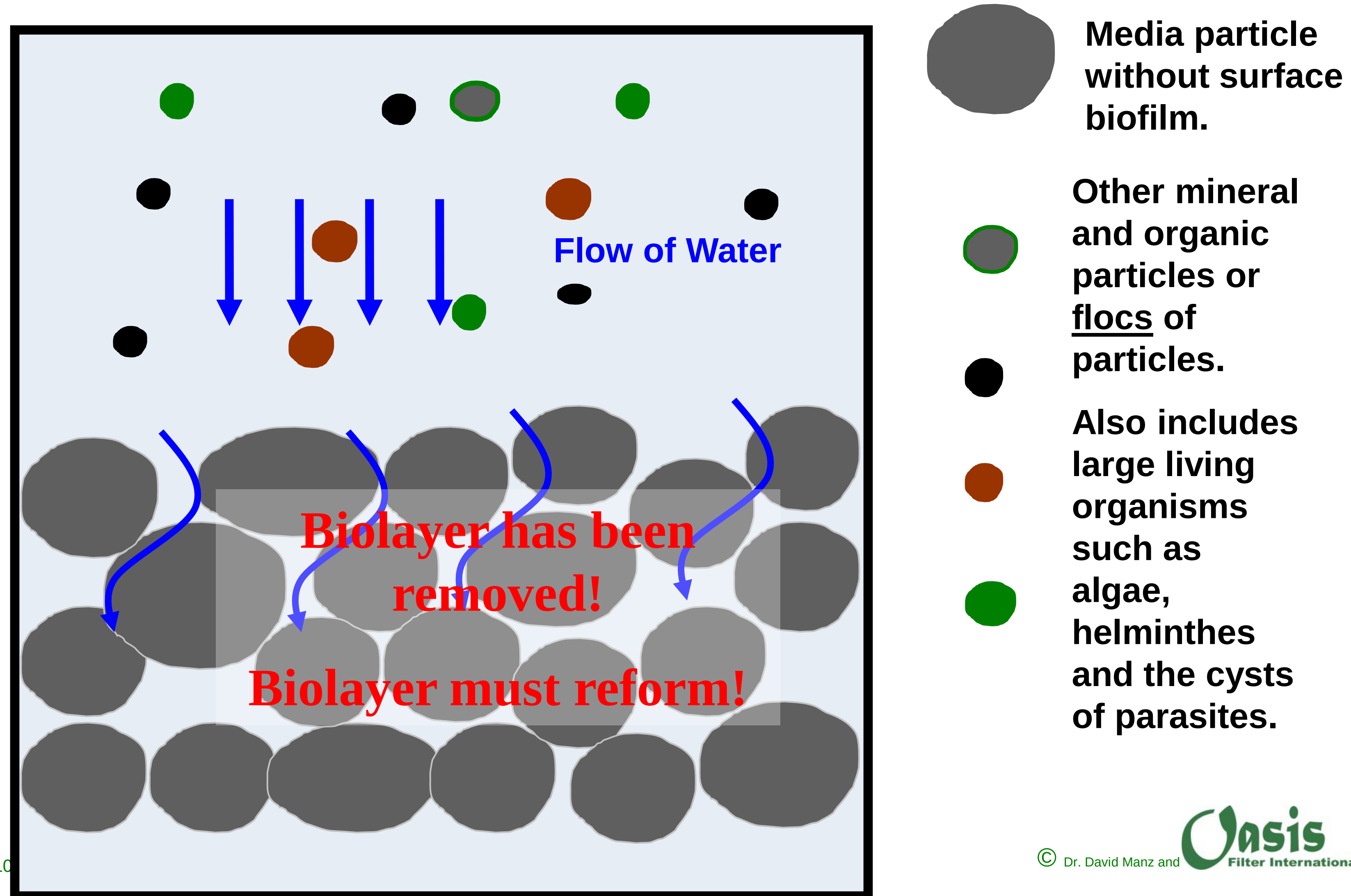
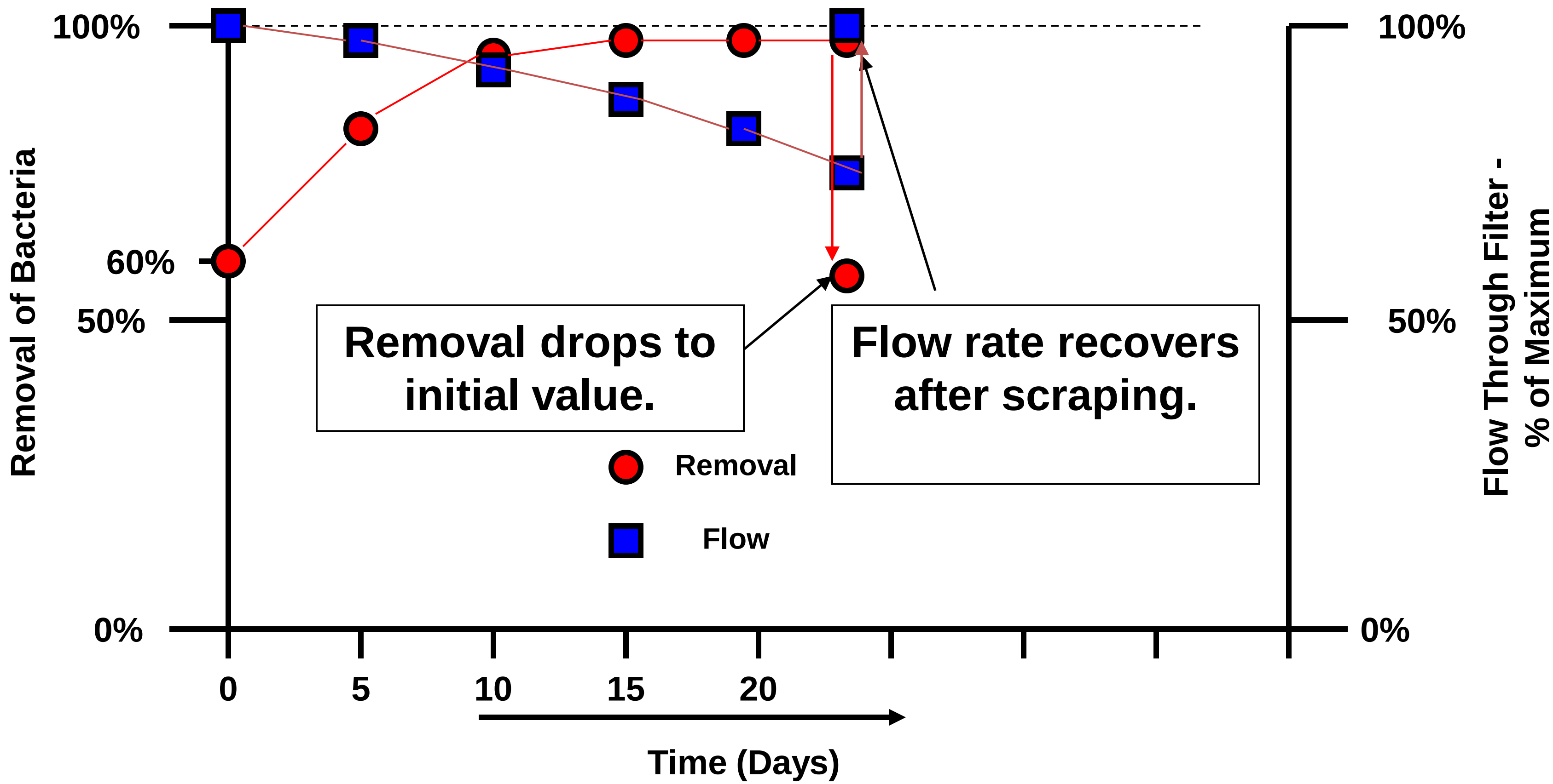

After Scraping #6.
Replacement Sand
Minimum Depth
Raw water is added to filter without disturbing surface of media.
Resuming Filter Operation.
Often ALL filter sand is replaced.

Cleaning a filter at the Vartry WTP near Dublin, Ireland

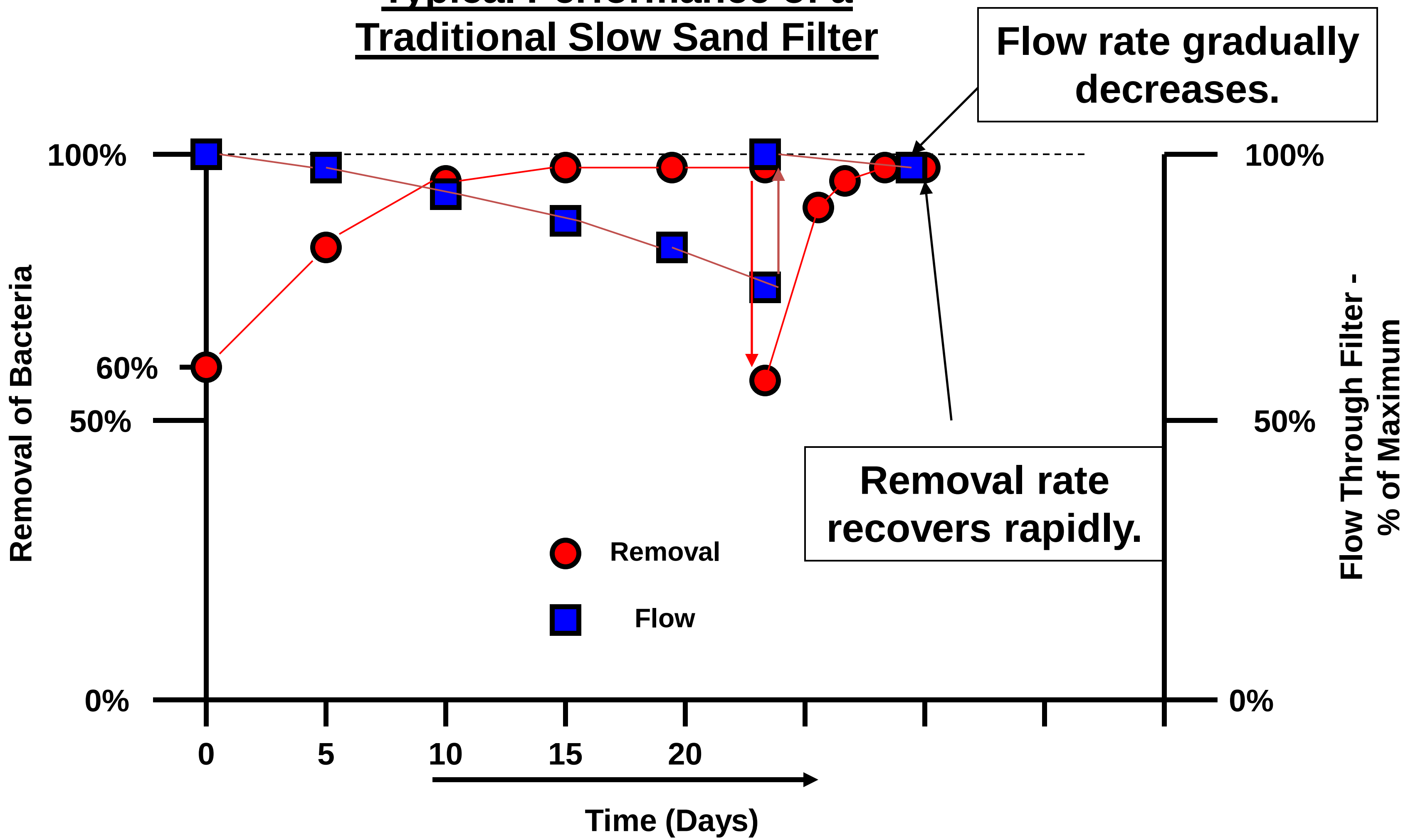
TSSF After Cleaning (Scraping)



Typical Performance of a Traditional Slow Sand Filter



Typical Performance of a Traditional Slow Sand Filter



Normal Cleaning of MSSF

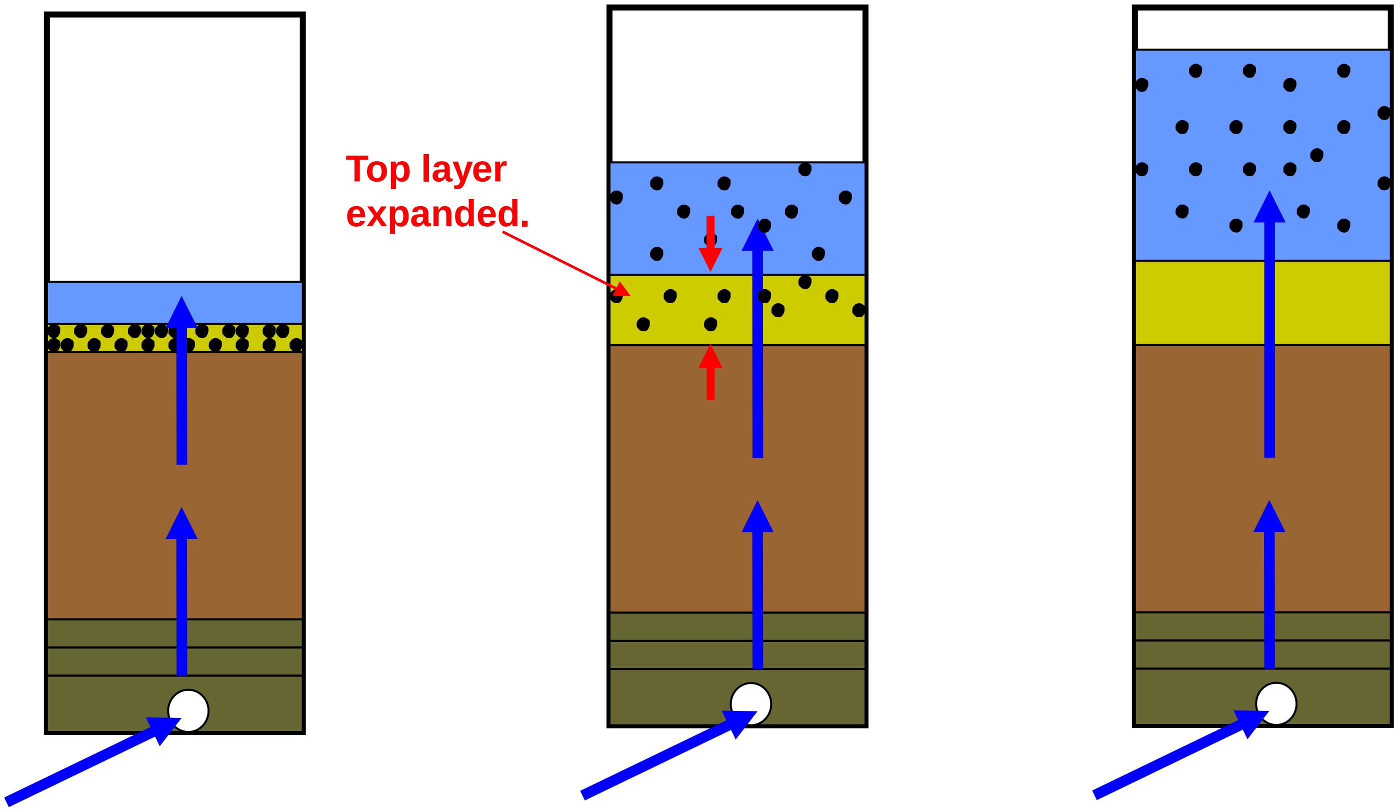
1. **Filtered water is added into bottom of filter – backwash flow.**
2. **Surface layer of media is fluidized and expanded.**
3. **Backwash flow is stopped and media settles back into position.**
4. **Water containing captured particles is flushed out.**
5. **Biolayer has not been removed and does not need to reform.**

Entire cleaning process takes less than 30 minutes even for very large filters.

No media is removed or needs to be replaced.

Normal Cleaning of MSSF

Backwashing removes particulate material that had blocked flow from top of media.

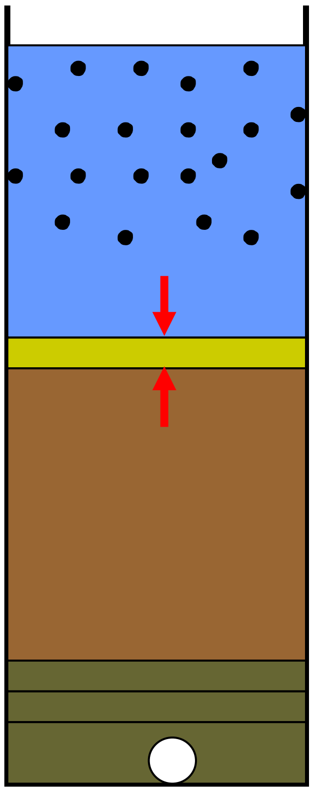


Filtered water enters filter.

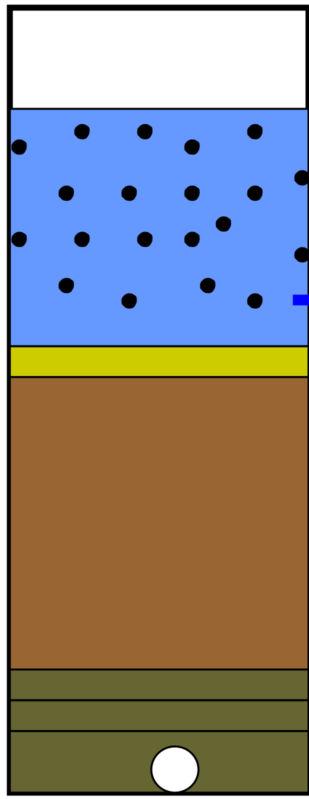
Only the layer of fine filtering media <u>needs</u> to be expanded and <u>captured particles are flushed</u> from it.

Backwash is stopped – smallest particles coated with biofilm remain at surface.

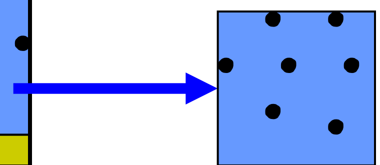
Not possible to lose media during backwash process!



Top layer collapses to original depth.



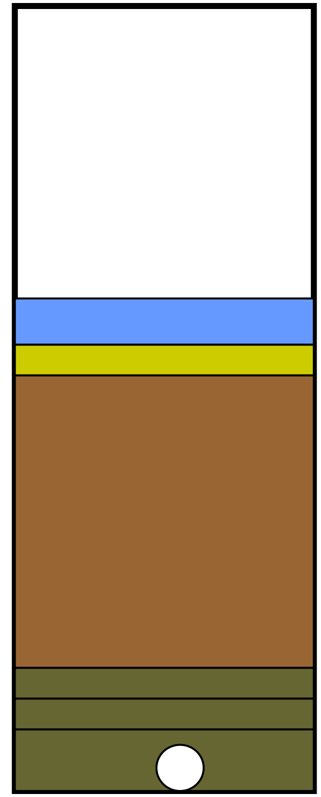
Water containing all of the captured material is decanted from filter.



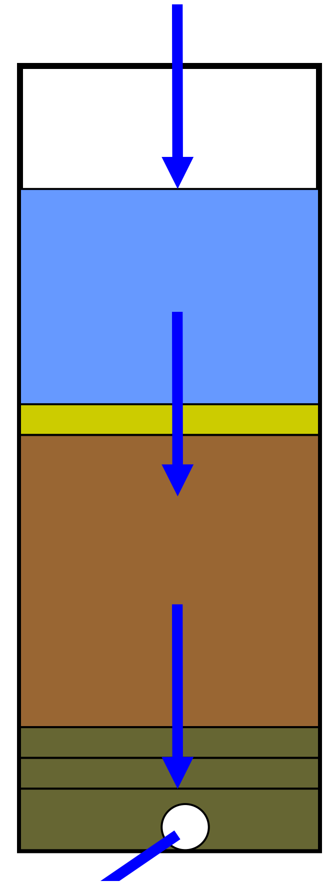
Decanted water is sent to waste.

Note that the wastewater does not represent a biohazard or a disposal problem if chemicals are NOT used.

Recycling wastewater may be practical.

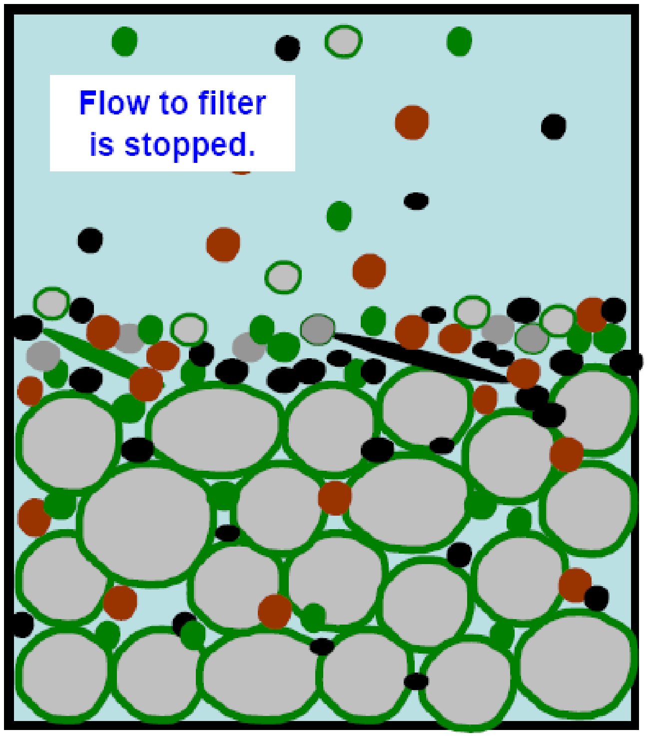


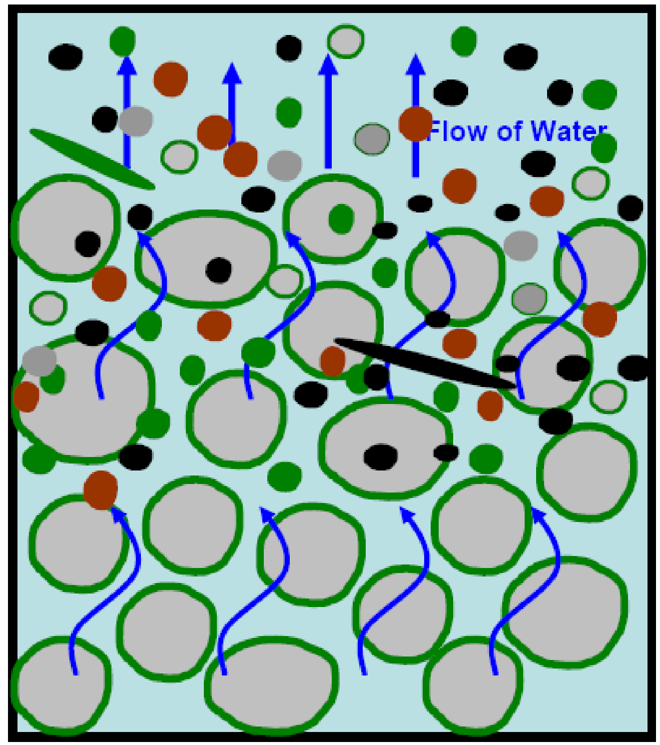
Decant is complete.



Filter is put into production without filter-to-waste cycle.

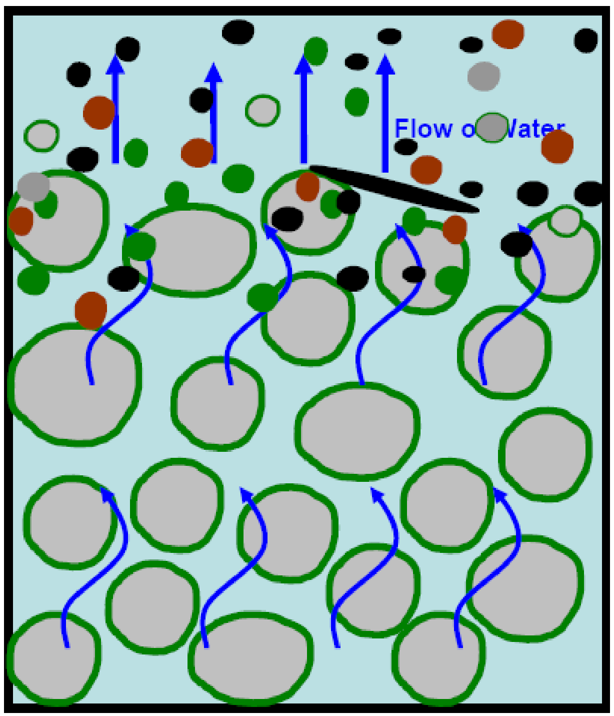
Cleaning the MSSF.



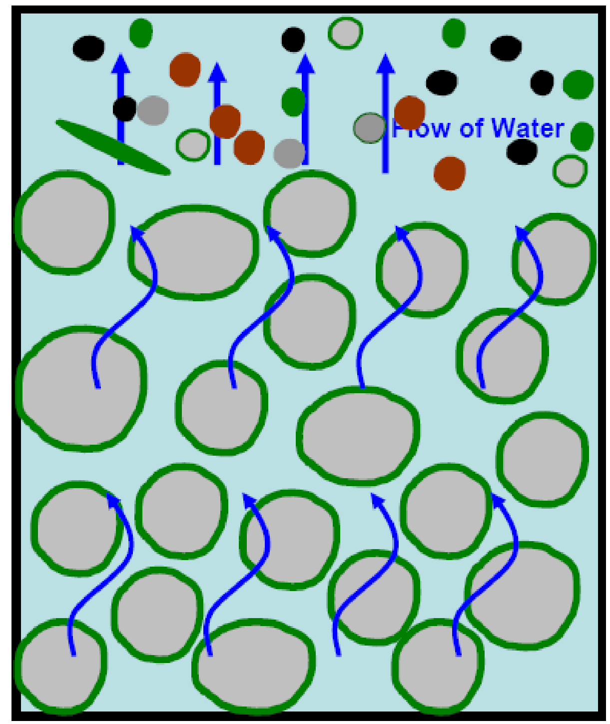


Backwash is started and bed fluidizes.

Cleaning the MSSF.

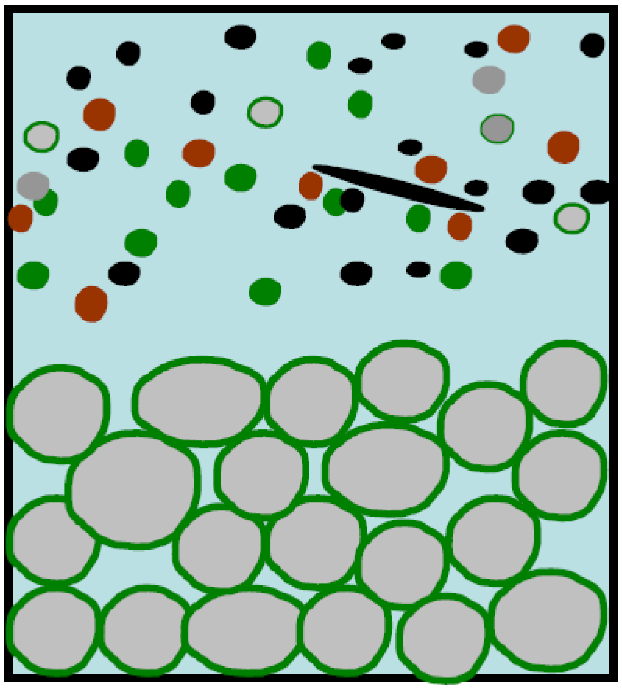


Backwash continues as long as required to flush particles blocking flow from filter.



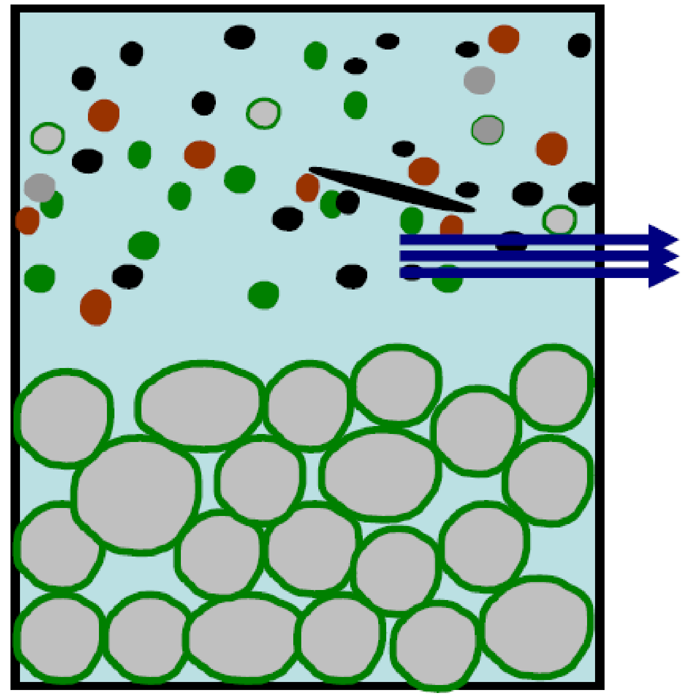
Particles blocking flow from filter are now in water above media.

Cleaning the MSSF.



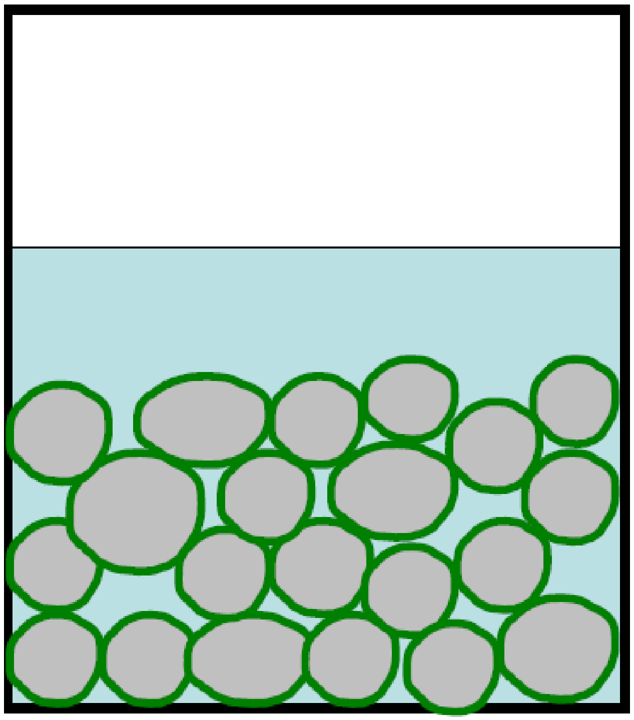
Backwash stops.

Particles, with biofilm settle into original pre-backwash position – on the surface of the media.



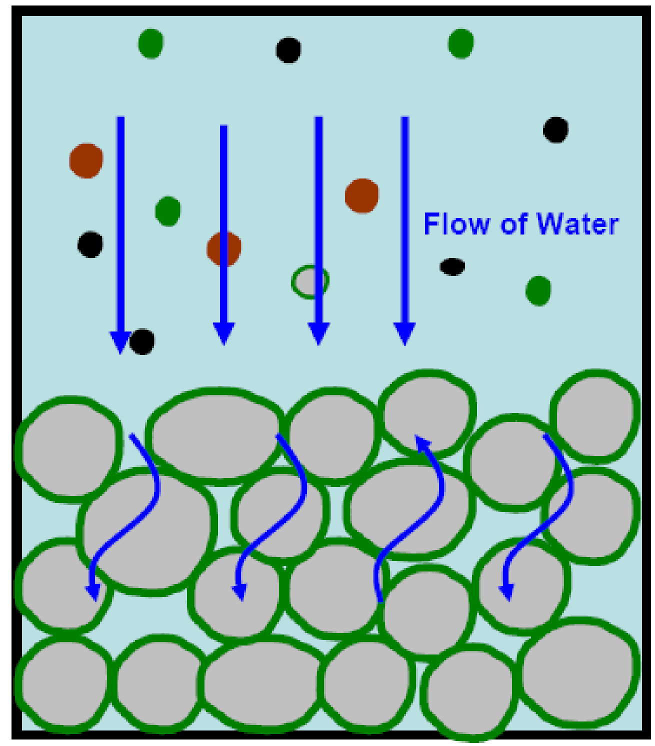
Water containing suspended particles is decanted.

Cleaning the MSSF.



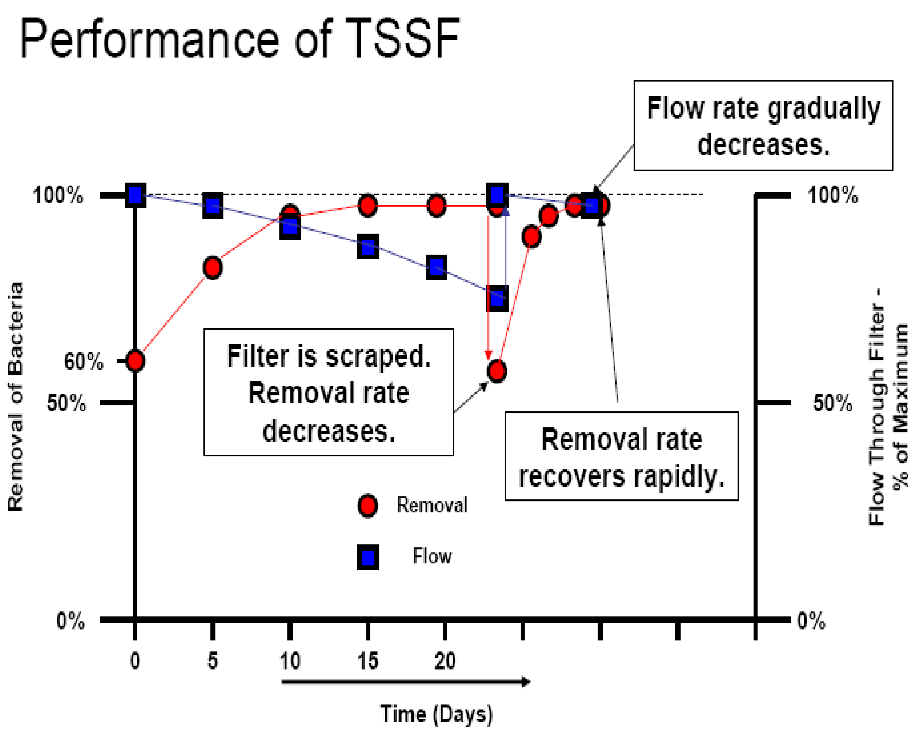
State of filter after backwash and decant complete.

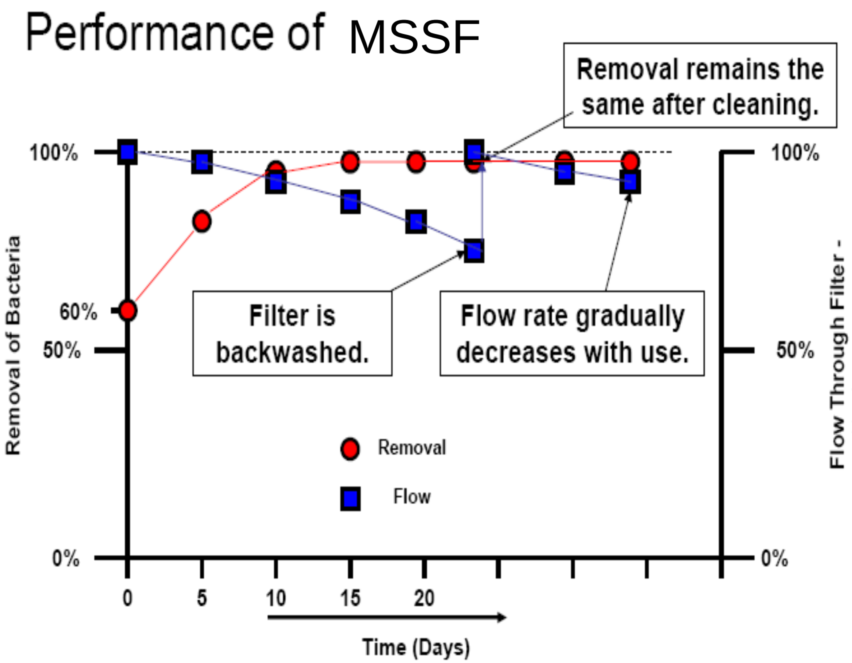
Note that the particles with biofilm are at the surface.



Filtration resumes.

Comparison of the performance of TSSF and MSSF for bacteria removal.





No loss of biolayer when cleaned.

Pathogen Removal with Post-Filtration Disinfection**

	Removal Rate %	
Pathogen	**TSSF**	**MSSF**
Helminths	Up to 100	Up to 100
Parasites	Up to 100	Up to 100
Bacteria	Up to 100	Up to 100
Viruses	Up to 100	Up to 100
Spores	Up to 100	Up to 100

** Typically some form of UV and/or chlorine disinfection. Parasites and helminths are removed by filter.

Particulate Removal

	Removal Rate %	
Parameter	**TSSF** Turbidity < 20 NTU	**MSSF***** Turbidity < 200 NTU
Sand	100	100
Silt	100	100
Organic Particles	100	100
Clay Particles	Up to 100	Up to100

*****Simple to clean** and **does not consume any filtering media**. ***Pretreatment using low concentrations of coagulant is very effective and practical. Roughing filters are practical when water quality has sustained higher turbidities.***

Note: ***Research is published that suggests that slow sand filters remove cryptosporidium without associated turbidity reduction.***

This is unlike conventional treatment using coagulants-clarification-rapid sand filtration where turbidity is closely correlated with cryptosporidium removal.

Regarding Operation of Slow Sand Filters (SSF) in Cold and Warm Climates

Contrary to what many engineers believe, removal of pathogens using slow sand filtration technology is NOT a problem when the water being treated is cold – at temperatures slightly above 0^{o} C.

Pathogen removal at temperatures slightly above 0^{o} C should be similar to that at warmer temperatures – up to 45^{o} C or higher!

Note Regarding Operation of SSF's in Cold Climates

1. **Air binding that results from warming of cold water within the filter media of Traditional SSF's. (Resolved using the MSF technology during the back wash process.)**
2. **Attempting to treat water from close to the bottom of shallow lakes or reservoirs in mid-winter. (anaerobic, high DOC, colour, odour, high TSS, etc.) which results in the need for frequent scraping and sand replacement. The solution is to raise the intake nearer the surface or refit the Traditional SSF to use the MSF technology – no scraping or resanding and the possibility of using alum to aid TOC removal. (Bench scale and pilot testing essential.)**
3. **Harrowing the surface of the filter is an absolute NO! NO! Harrowing a SSF destroys the biolayer and ability of filter to remove pathogens.**

When pathogens are not present, such as groundwater not under direct influence of surface water, the MSSF technology can be used as an effective, inexpensive polishing sand filter.

Under these circumstances it is not necessary to closely follow design guidelines for slow sand filters.

In Summary
MSSF Based Treatment Systems are:

- Low capital cost
- Low operating cost
- Sized for any demand
- Simple to operate (may be manually or automatically operated)
- Low maintenance
- Efficient (allow maximum production from a slow sand filter)
- Environment friendly (minimum use of chemicals and production of wastewater that may be recycled)

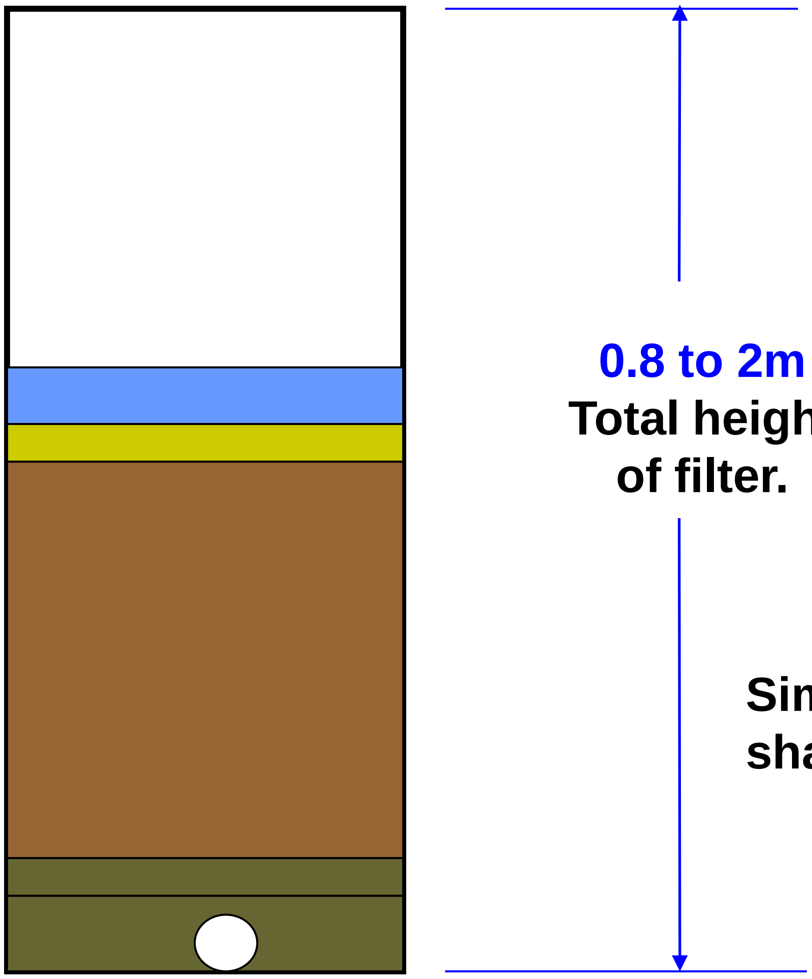
- Easily used with other pre- and post-treatment technologies
- Easily constructed on site or as part of a package plant
- Appropriate for readily accessible and remote applications
- Appropriate for treatment of a wide variety and range of water quality
- Easily evaluated (bench scale and pilot)

As well MSSF Based Treatment Systems allow:

- **Retrofitting of existing TSSF installations to use MSSF technology achieving**
  - **Greater treatment capacity**
  - **Much less effort to clean**

- **Treatment and recycling of waste water from conventional water and waste water treatment plants**

Manz Polishing Sand Filter (MPSF)

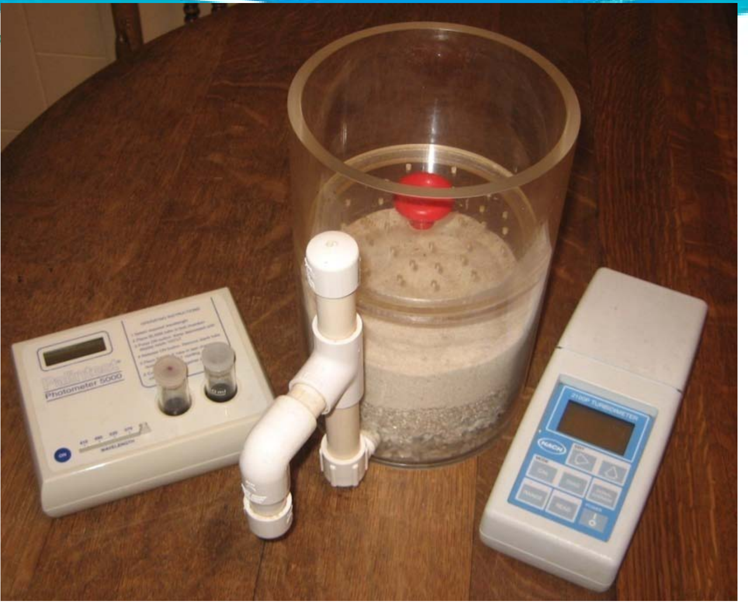


Loading up to 0.6 $m^3/h/m^2$ of surface area or greater.

Design established using bench and pilot scale evaluations.

Similar to MSSF or shallower.

Bench scale evaluation is simple to perform:



Pilot testing is simple to perform:

MPSF's

Are constructed and operated in a <u>similar manner</u> to MSSF technology with all of the same advantages.

MPSF

based treatment systems are simpler and less expensive than treatment systems using other filtration technologies.

MPSF
Based Treatment Systems may be used to remove small particles such as:

- Particulate matter (sand, silt or clay sized particles with or without use of coagulants)
- Iron (directly or using pre-oxidation)
- Manganese (directly or using pre-oxidation)
- Hydrogen sulphide (using pre-oxidation)
- Arsenic using pre-oxidation and coagulants
- Fluoride (using lime and coagulants)
- Heavy metals (with use of appropriate coagulants)

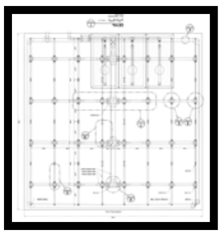
- **TOC/DOC (using coagulants or pre-oxidation)**
- **Algae (directly or with pre-disinfection and use of coagulants)**
- **Parasites including Giardia Cysts and Cryptosporidium Oocysts**
- **Helminthes and their eggs**
- **Spores**

MPSF Based Treatment Systems may be used to treat:

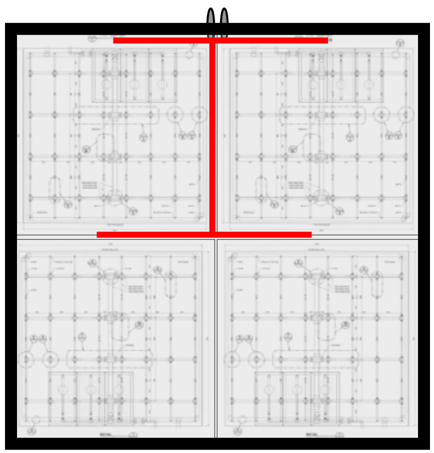
- Surface water
- Ground water
- Brackish or saline water as part of pre-treatment for desalination process
- Polishing filtration for municipal wastewater that has been treated to tertiary (perhaps secondary) standards
- Storm water runoff
- Industrial or municipal wastewater to condition satisfactory for reuse and recycle or disposal
- Agricultural wastewater to condition satisfactory for reuse and recycle or disposal
- Rainwater

MSSF/MPSF cells can vary in capacity.

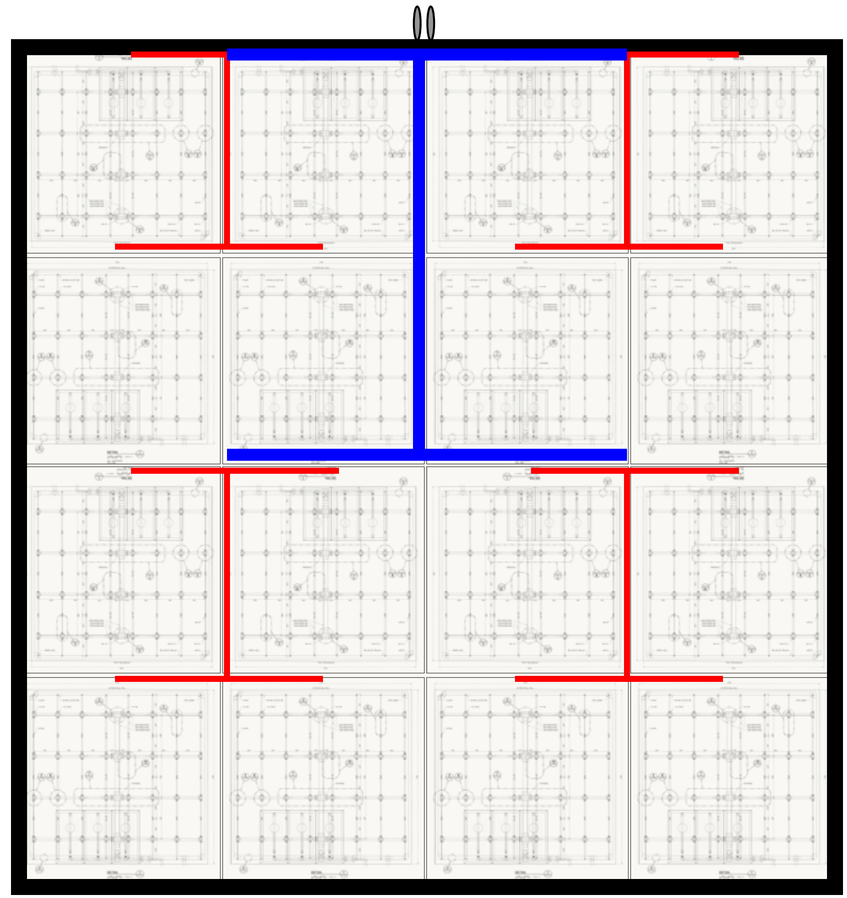
300 - 10,000 L/h



40,000 L/h



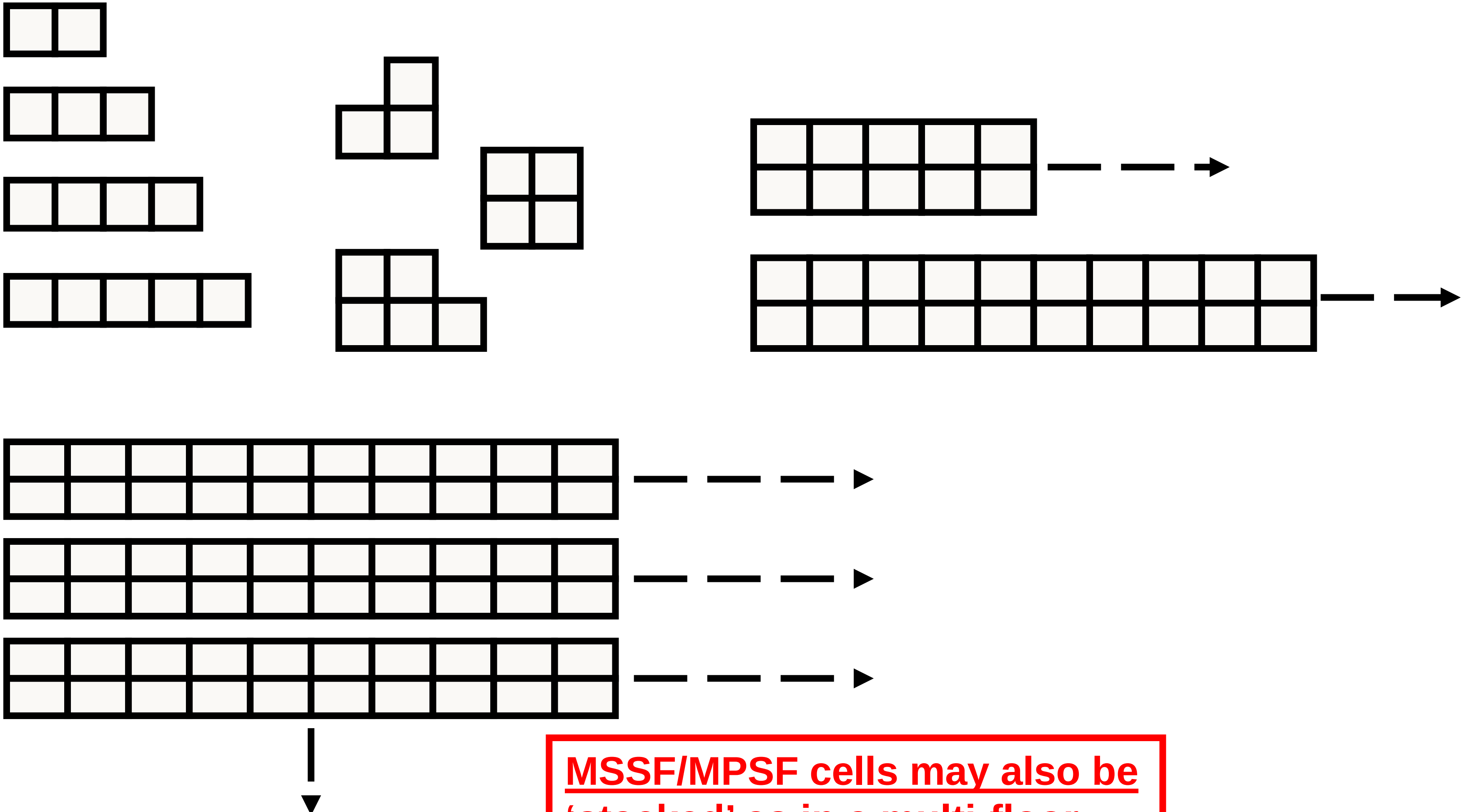
160,000 L/h



Any shape.

Designs have been evaluated at proto-type scale.

Possible configurations of MSSF/MPSF cells.



MSSF/MPSF cells may also be 'stacked' as in a multi-floor building.

Applications of MSSF/MPSF Technology

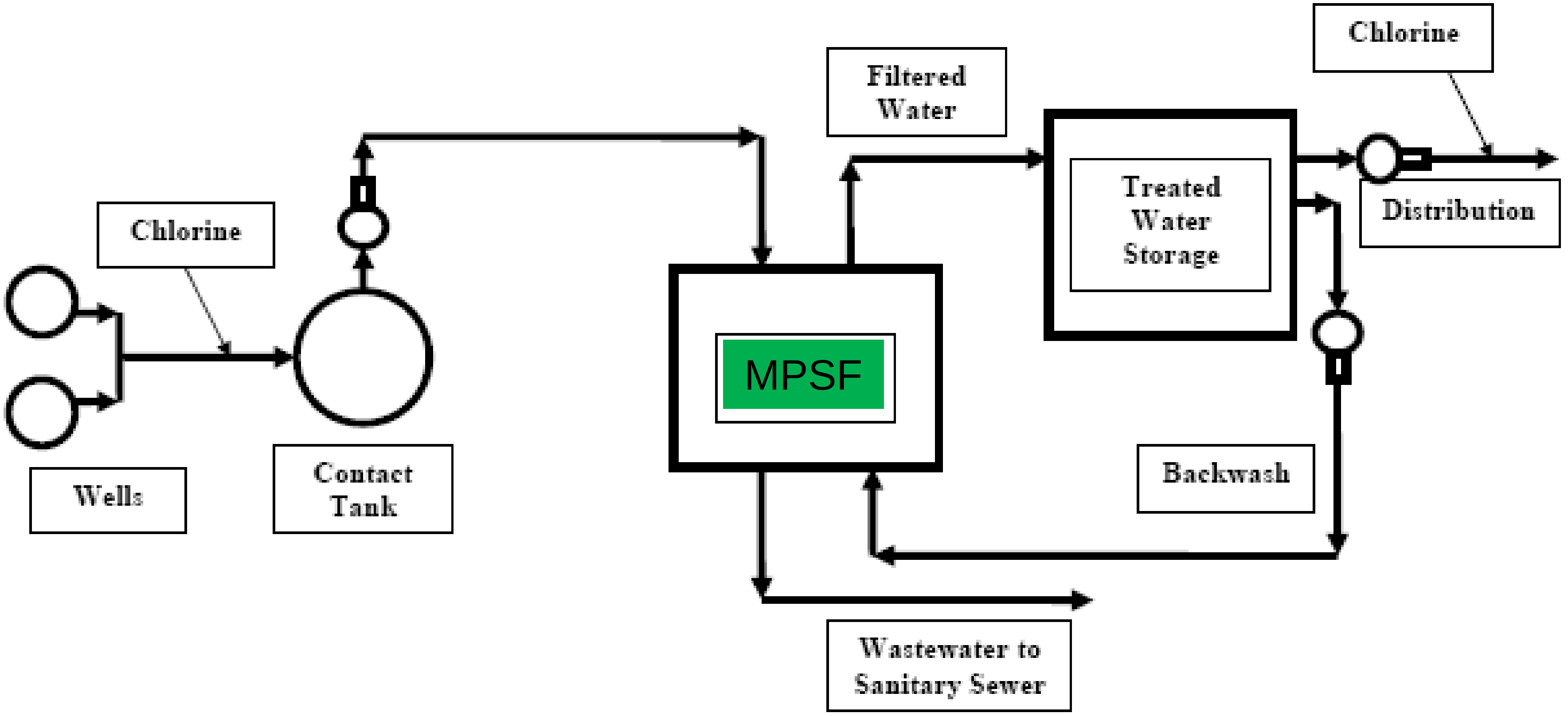
Stavely Water Treatment Plant
Alberta, Canada
Manganese Removal Using MPSF Technology

Stavely Water Treatment Plant

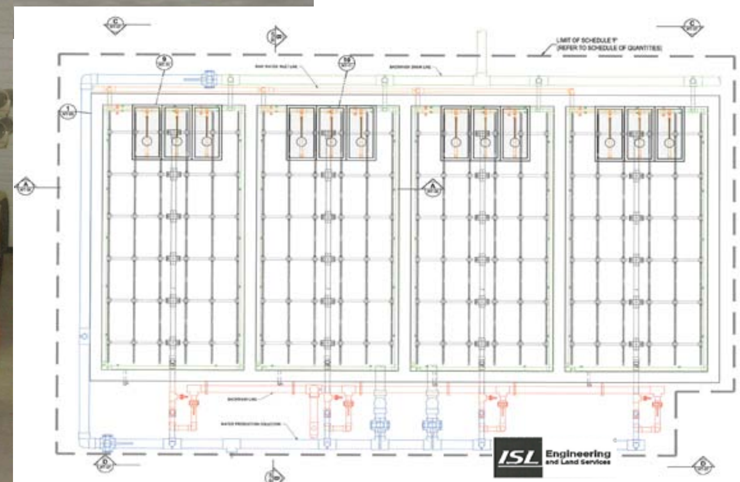
50,000 L per hour.

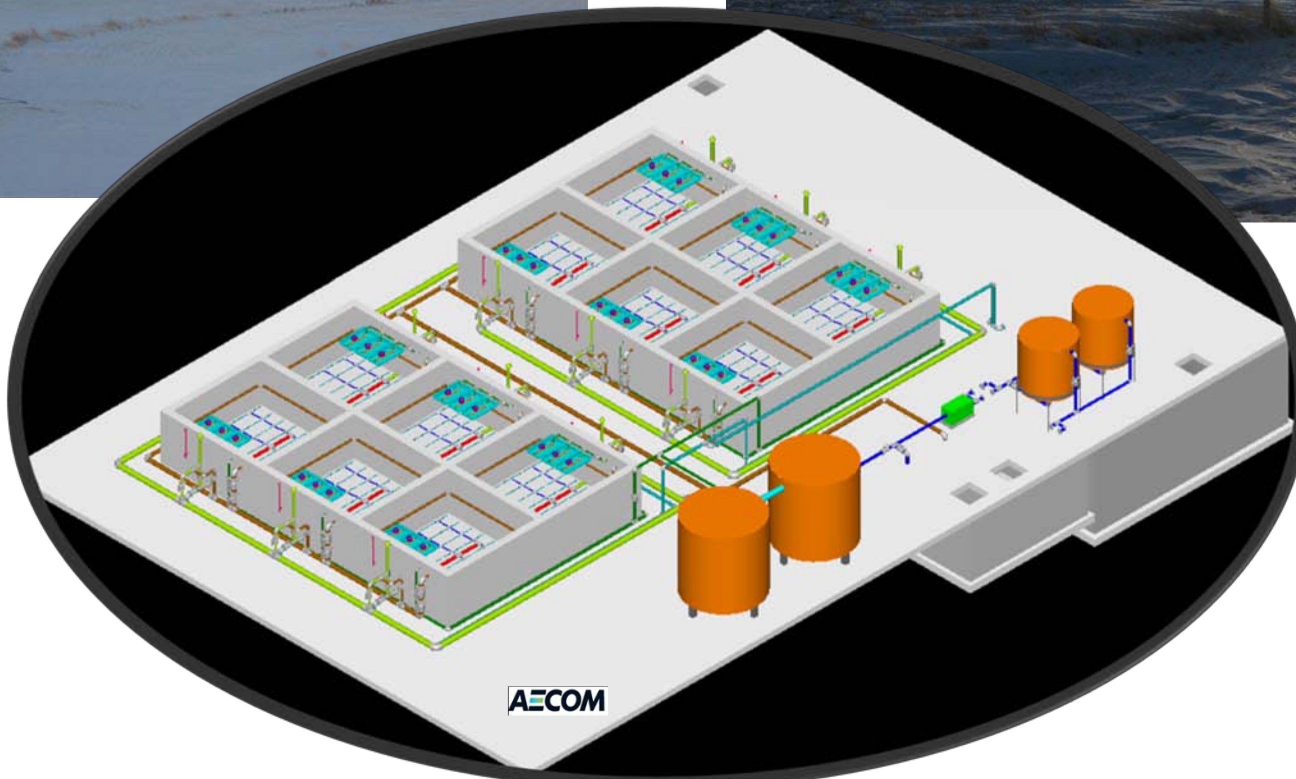
There are several other projects in Western Canada in the planning stages.

Process Flow Diagram - Stavely



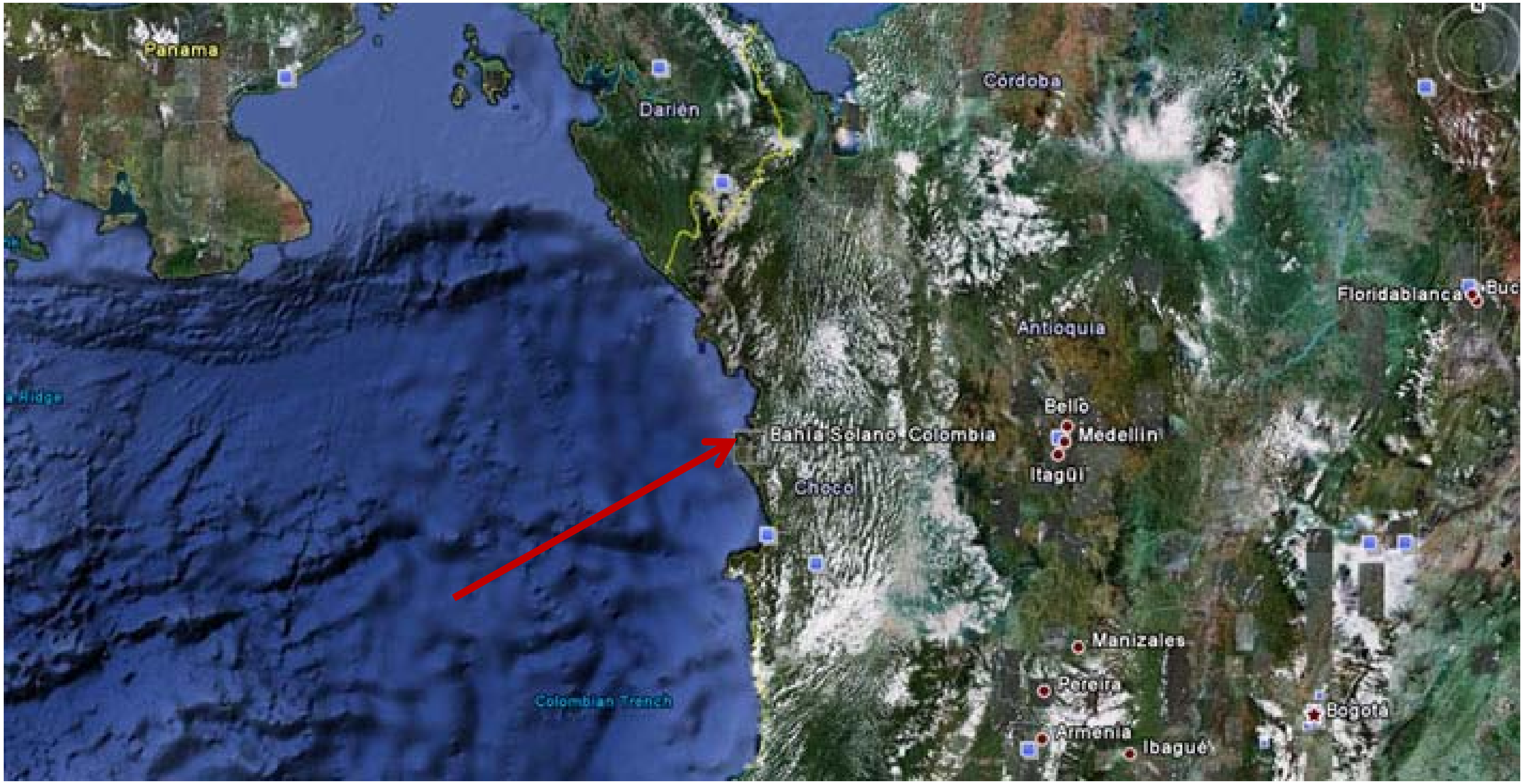
Water treatment plant using MPSF technology in Exshaw, Alberta, Canada now under construction – 50,000 LPH expandable to 100,000 LPH.





Water treatment plant using MPSF technology Saskatchewan, Canada that will be constructed 2011- 100,000 LPH.

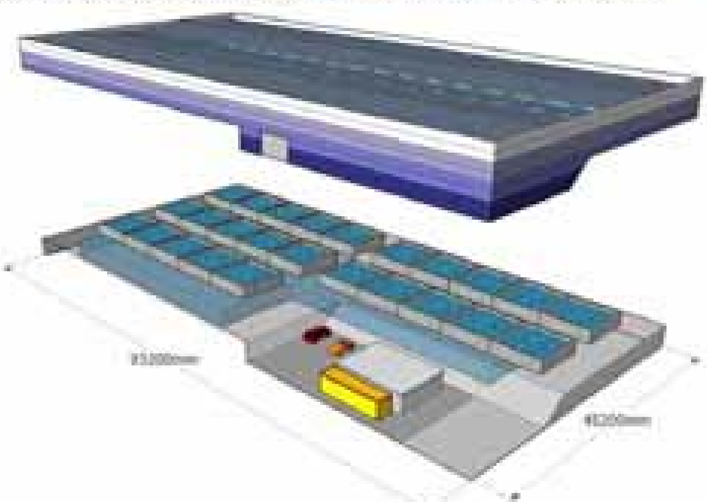
Pacific Northwest of Colombia (Chocó) - December 2009
MSSF (4500 LPH)



Fibre glass 4500 LPH MSSF Treatment System in Chocó, Colombia.

CONCEPT / PROPOSAL DRAWINGS FOR UPGRADE TO EXISTING WATER TREATMENT PLANT

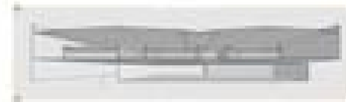
IMPACT OF PROPOSED DEVELOPMENT IN THE LANDSCAPE



DIAGRAMMATIC LAYOUT OF PROPOSED WATERWORKS

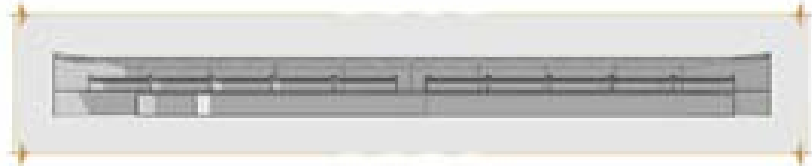
CONCEPT / PROPOSAL DRAWINGS FOR UPGRADE TO EXISTING WATER TREATMENT PLANT

- **625,000 litre/hour (15,000,000 litre/day) production**

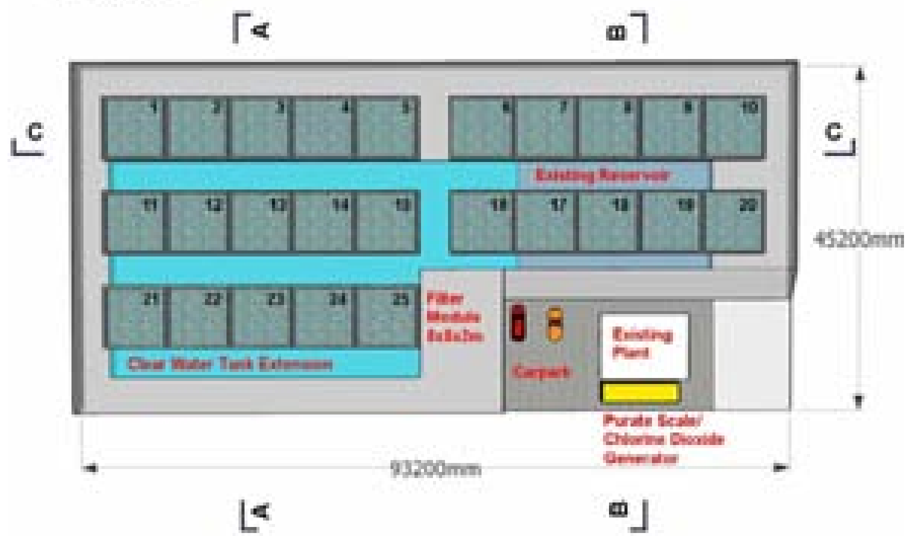


SECTION A-A

SECTION B-B



SECTION C-C



PLAN VIEW OF PROPOSED WATERWORKS

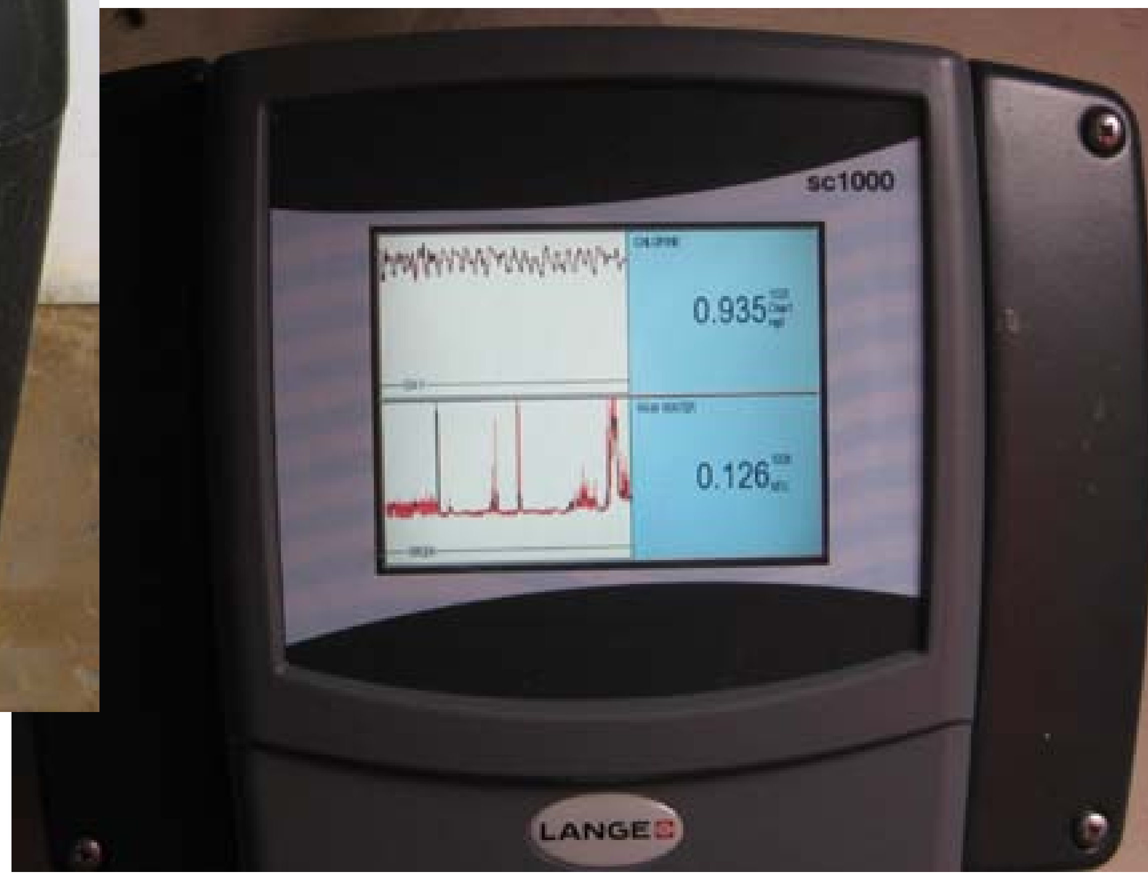
PILOT PROJECT

Shrone, County Kerry, Ireland

March 2009

Current water treatment: addition of sodium hypochlorite

Problems with turbidity spikes



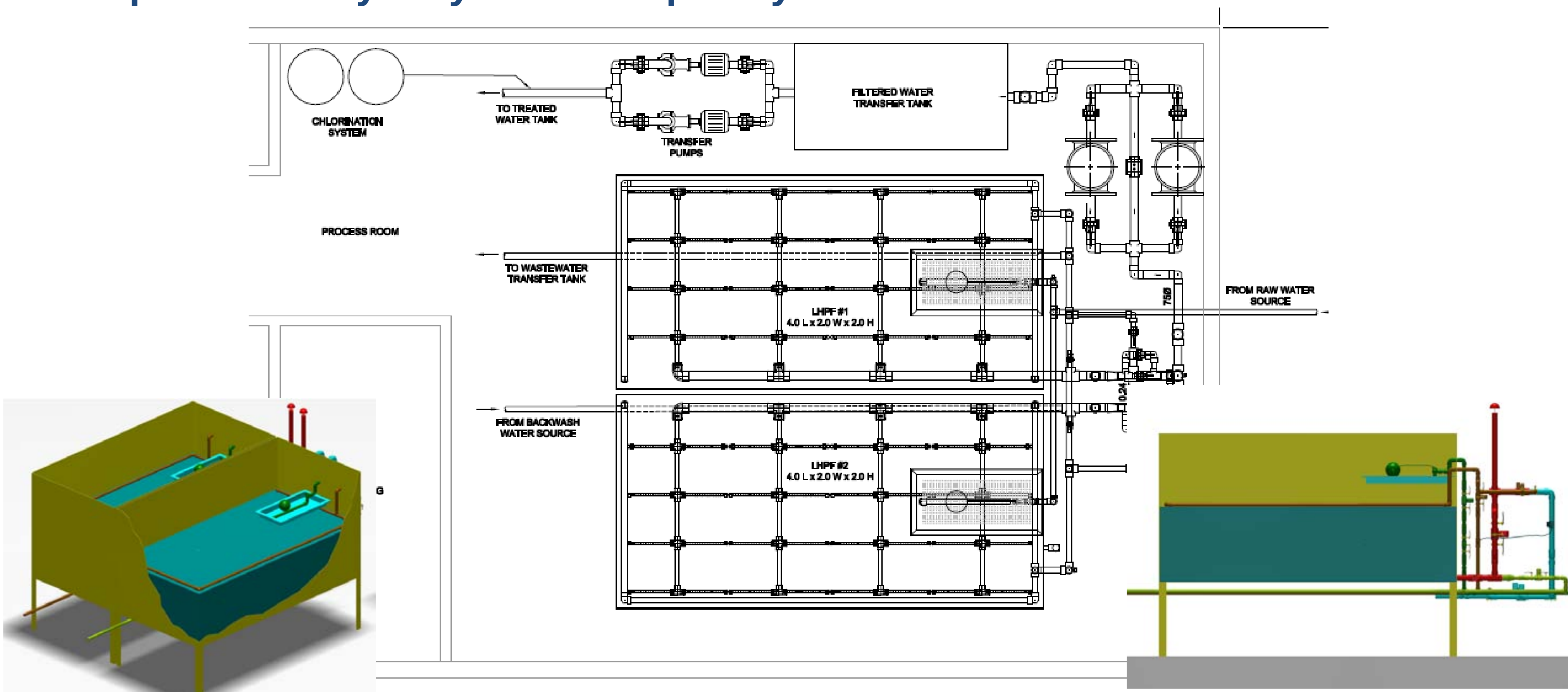
Pilot MSSF unit

1,000 litre/day

NWT, Canada Water Treatment Plants (MSSF Technology).

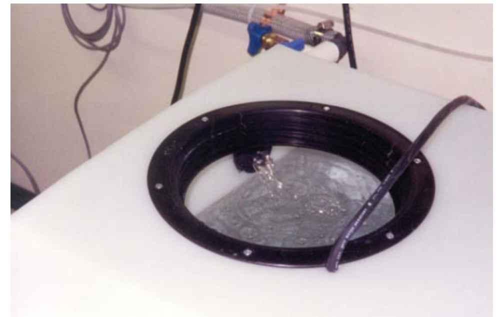
Example of Design of Small Scale Water Treatment Plant

- 8,000 litre/hour (190,000 litre/day) production.
- Surface or ground water.
- Operation may vary from completely manual to completely automatic.
- Operation may vary from completely local to full remote control.



Stoney Adolescent Ranch

Alberta, Canada



- **Surface water (Bow River) and groundwater for iron.**
- **2x 240 lph filters with chlorine disinfection.**

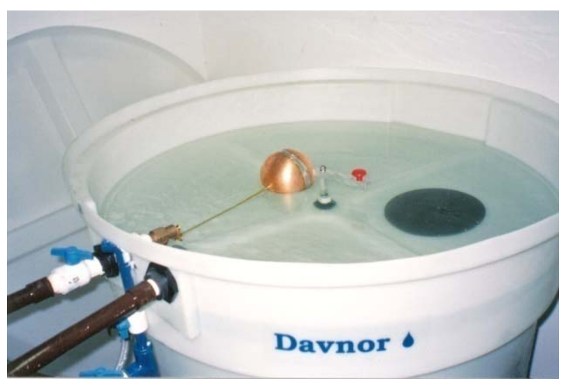
Seymour Arm

Shuswap Lakes, B.C., Canada:

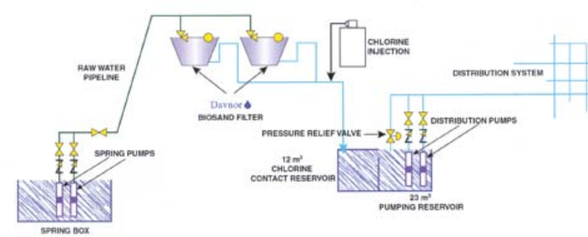
- **Drinkng water only.**
- **2x240 lph filter followed by UV disinfection.**
- **Serves 110 cabins, camp ground and a small hotel and restaurant.**
- **Self serve.**
- **Generates own hydropower.**

East Morley, Alberta, Canada

- Shallow spring.
- 2 x 600 lph filters used in parallel followed by chlorine disinfection.

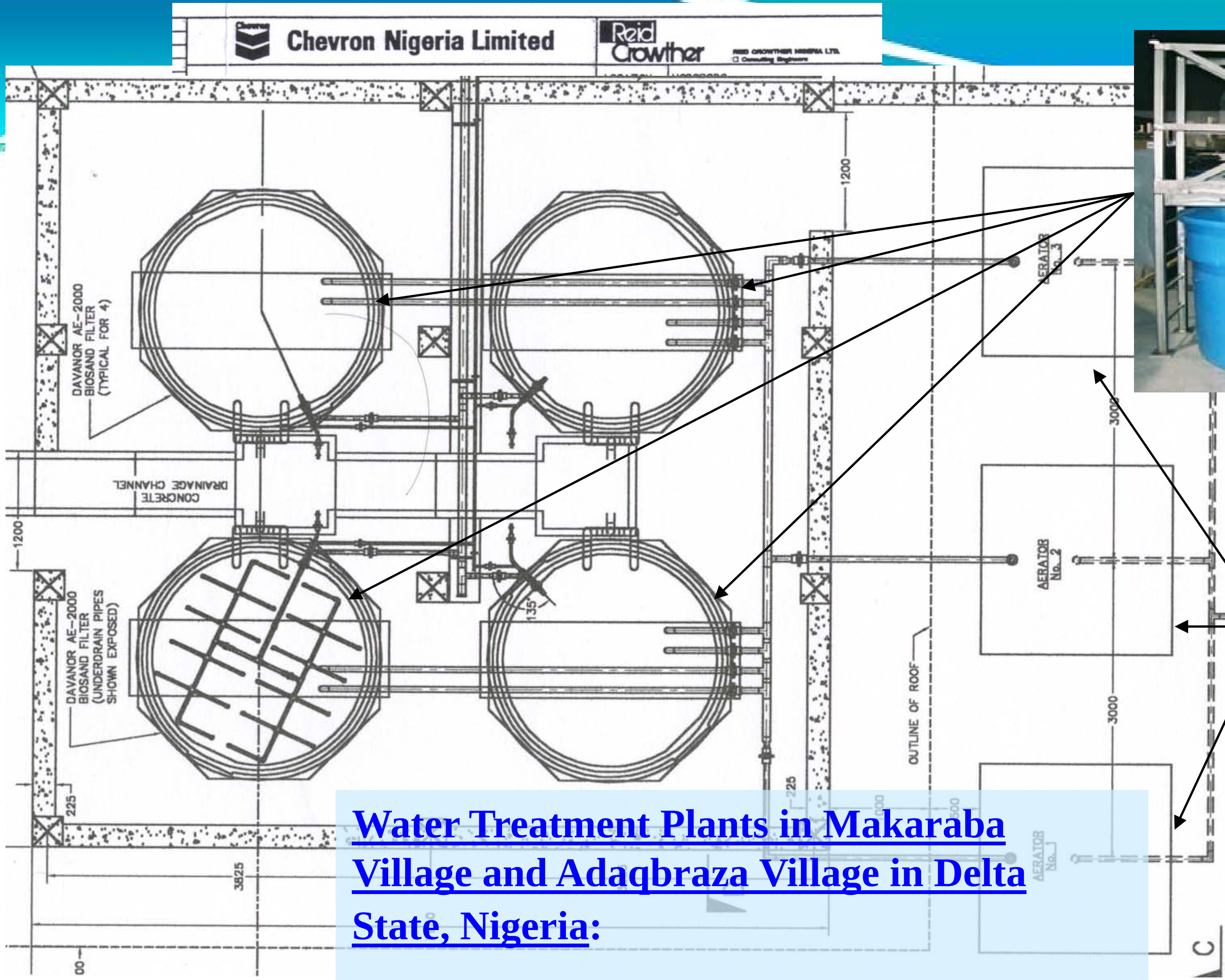


EAST MORLEY WATER TREATMENT PLANT SCHEMATIC



WATER SYSTEM STATISTICS

Current Number of Homes Serviced	5
Maximum Water Supply Volume	23 m^3/day
Water Supply Pumps (2)	25 L/Min
Treatment Process	Slow Sand Filtration (Davnor Biosand Water Filter)
Chemicals Added	Chlorine for Disinfection, dosed by supply flow rate.
Distribution Pumps (2)	40 L/Min
Distribution Operation	Based on Pressure



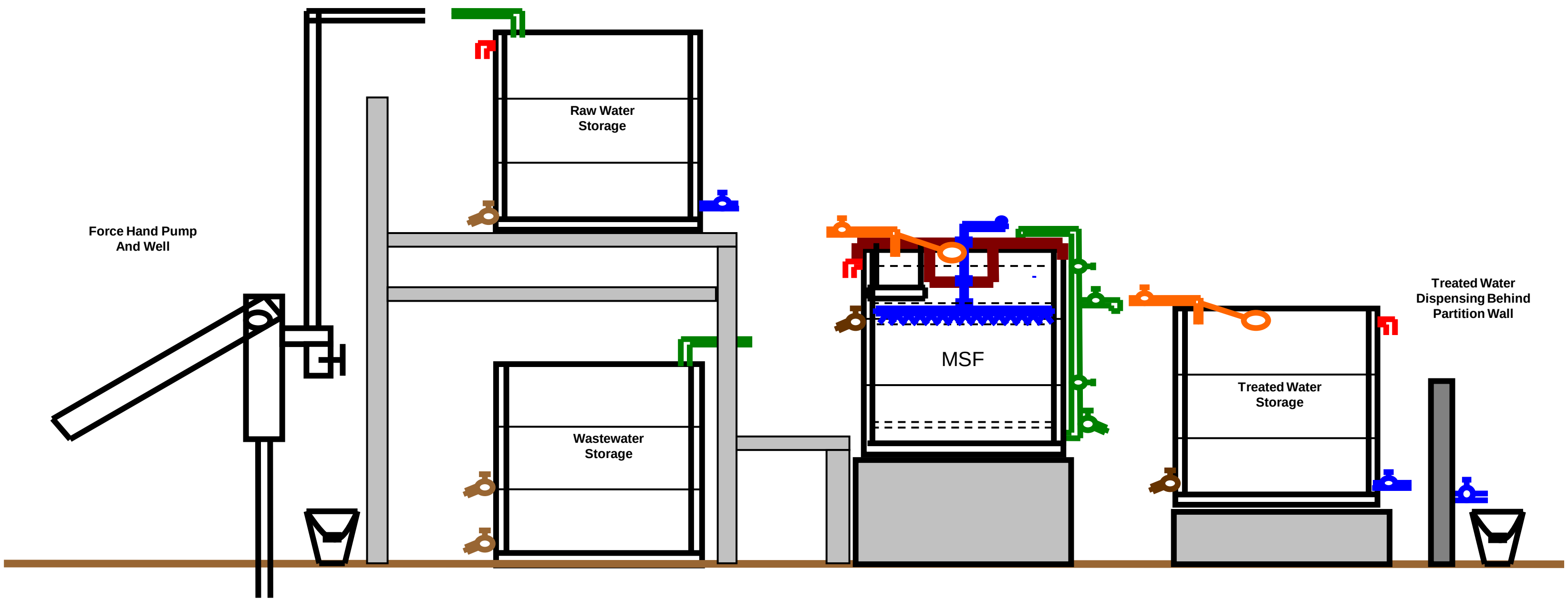
2,000 lph Water Filter

Aerator

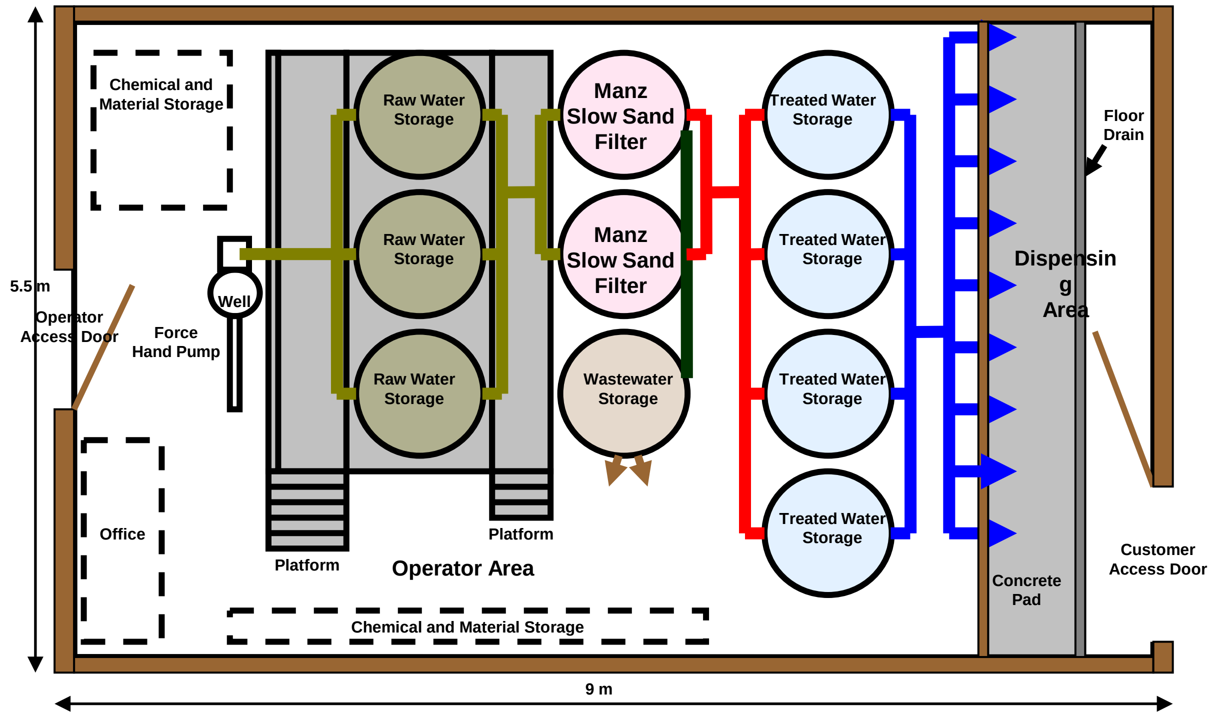
Water Treatment Plants in Makaraba Village and Adaqbraza Village in Delta State, Nigeria:

- Groundwater with iron.
- Treatment consists of aeration followed by 4x2,000 lph Water Filters chlorination for purposes of iron removal.

Example of MSSF Community Scale Water Treatment Plant for developing countries



Elevation View of the MSSF Community Scale Drinking Water Station V 1.0 (Drawn approximately to scale.)



Layout – (Approximately to Scale) – of the MSSF Community Scale Drinking Water Supply Station

- 900 litre/hour (21,600 litre/day) production
- Backwash tank could be added as required

Important characteristics of MSSF/MPSF technology:

Provides Cryptosporidium barrier similar to TSSF

- **Able to treat water with higher turbidity (easily and quickly cleaned - accommodate turbidity spikes)**
- **Eliminate or minimize ripening period (biolayer is always present)**
- **Eliminate possibility of short-circuiting or air-binding.**
- **Minimize/eliminate need for re-sanding**
- **Low capital cost**
- **Low operating cost**
- **Minimum use of energy**

- Ability to use chemicals for suspended solids reduction or colour reduction (TOC reduction)
- Minimal waste water production and associated need for disposal
- Easily evaluated using simple bench scale testing and pilot testing
- Easily used with other treatment technologies for turbidity and TOC reduction
- Practical for use in very small to very large treatment systems
- Filtration capacity is easily expanded to accommodate future growth

- Existing TSSF installations can be retrofitted to use MSSF technology
    - Greater capacity
    - Much less effort to clean
- Treatment and recycling of waste water from other treatment processes used in water and waste water treatment plants (e.g. Waste water from rapid sand and ultra filtration)
- Polishing filtration for municipal wastewater that has been treated to tertiary (perhaps secondary) standards

Thank you.