



Bring Your Own Water Treatment System – Pump Driven Configuration

Build, Operation, and Monitoring Manual

Trae Su Propia Sistema- Tratamiento de Agua Bombee Configuración Conducida

Manual de Operaciones

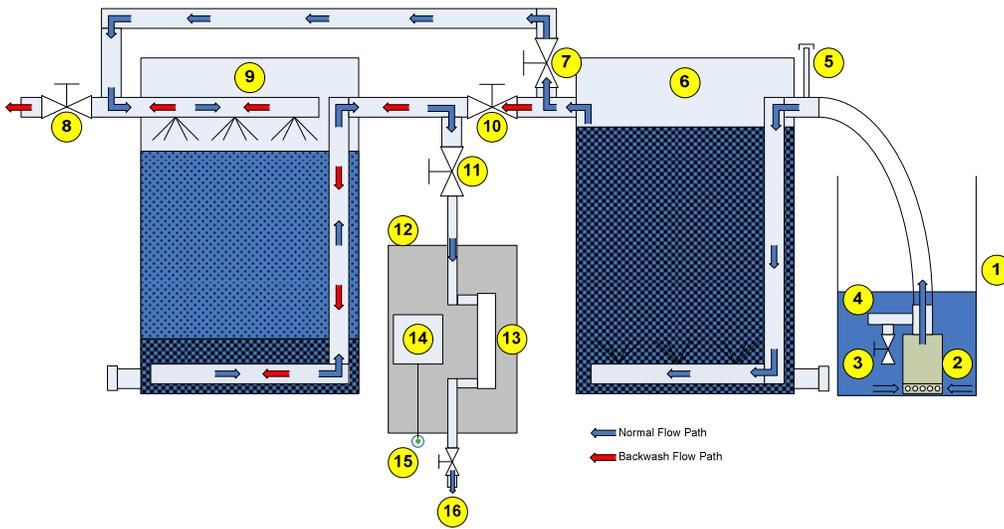


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1.0 Background

Over a billion people in the world lack access to safe drinking water. While numerous technological, medical, and educational solutions have been implemented for the benefit of disadvantaged communities, there is no ‘magic bullet’. Instead, development agencies must partner directly with these communities to address their public health needs through appropriate technology solutions backed up by education and assessment.

The “Bring Your Own Water (BYOW) Treatment System” developed by Engineers Without Borders-USA is uniquely designed to address the water treatment requirements of rural communities. The BYOW system consists of a gravity-fed roughing filter, rapid sand filter, and solar-panel powered electrical ultraviolet irradiation system. The BYOW system treats water collected in containers by local residents. A key component is a self-filling tank for backwashing of the filter. The system treats water at a rate of approximately 10 liters per minute, and can provide up to 8,400 liters of treated water per day. The BYOW system performed successfully in long term tests in Houston, Texas, where wastewater (over 70 NTU turbidity, 3000 CFU / ml E. Coli) was inputted and the effluent water was significantly cleaner (less than one NTU, 0-2 CFU / ml E. Coli).

The BYOW system has the potential to be successfully replicated around the world where communities have similar social and economic constraints and water treatment requirements.

2.0 System Description

Water-borne disease is a leading cause of illness in the developing world, contributing to the death of 15 million children every year, on average. However, there has yet to be developed a catch-all technology that can successfully be implemented in most developing communities. The BYOW system developed by several EWB-USA chapters is a unique assembly of previously proven water-treatment technologies that directly addresses the specific constraints and requirements of rural communities. This system and its subsequent iterations have the potential to directly address the biggest public health concern in many communities around the world. This project directly addresses several of the United Nations Millennium Development Goals (MDG), including *reducing child mortality, improving maternal health, combating disease, ensuring environmental sustainability, and developing a global partnership for development.*

The BYOW Treatment System combines several water treatment approaches. The first treatment step in the system is the gravel roughing filter. Incoming water enters the roughing filter from the bottom of the inclined drum and flows upward through gravel media with an average diameter of 1". As the water travels through the gravel, gravity causes entrained sediment to sink downward below the distribution arms into a sediment catchment basin.

Next to this roughing filter is a backwash tank with a valve that automatically diverts a portion of the input water and stores it for later backwash of the rapid sand filter. The bulk of the water is piped downhill, with the vertical drop of 10-15 vertical feet, providing pressure for the Plastic Drum Sand Filter (PDSF). The PDSF, a rapid sand filter, is built from a watertight UN standard 55 gallon drum with a removable lid. It is designed to operate under pressure to increase filtration speed. In this implementation, the PDSF operates at a maximum pressure of 14 feet of water (6 psi, 41 kPa). Unfiltered water enters near the top of the filter drum and is distributed across the top of the media bed by perforated arms. The cross-shaped distribution arm is mounted on a PVC union fitting that allows the arm to swing upward and out of the way to facilitate maintenance access to the media bed.

Water is forced through the media by pressure from the column of water above it, removing particulates and bacteria. Because system pressurization is provided by each bucket of water added, the amount of treated water delivered to the user can be no greater than the amount introduced. Additionally, the water is provided within minutes, because the sand filter is already primed and pressurized with water added by previous users. The PDSF in the BYOW system differs from typical sand filters and borrows principles from both rapid and slow sand filter designs. The biggest departure from usual design is the minimal pretreatment before filtration. While typical filters have pretreatment processes or other types of influent control, the PDSF influent is quite variable with the only pretreatment process being the roughing filter. The predictable

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result of such a situation is that the filter will clog more rapidly and the effluent will be of lower quality than in a typical RSF (rapid sand filter) based plant.

During nominal operation, filtered water flows out of the PDSF into a solar powered UV reactor. The UV light deactivates much of the remaining bacteria in the water. The Ultraviolet disinfection system utilizes a commercial-off-the-shelf disinfection unit and ballast, the R-Can Environmental Sterilight 12 or 20 liter per minute units. The system is stored in a waterproof, locked Zarges aluminum box. The necessary electrical and plumbing connections are also enclosed in the box. The system is operated by actuating an electrical timer switch on the side of the box. This switch turns on the UV system ballast, providing power to the light, while also actuating an electrical solenoid valve to allow the water flow to from the system.

While the UV stage of the BYOW system is considerably higher technology than the PDSF and roughing filter, failure of the UV would not completely disable the BYOW system, as users would still receive filtered water better than the average input.

A long term test was conducted on the BYOW system using activated sludge, a by-product of wastewater treatment, as the primary contaminant in the influent water. Activated sludge was used because it is primarily bacteria flocs, and therefore the turbidity in the water tracks bacterial contamination well. This long term test involved an automated batch dosing system that mixed activated sludge with clean water and then pumped the mixture into the system at a rate of approximately seven liters per minute. Each batch was approximately 100 liters, and around seven batches were run per day separated by two hour intervals. In total, about 8,800 liters of wastewater at around 75 NTU (measured with a Hach 2100P Turbidimeter) were pumped into the BYOW-PUMP system over ten days. The test was stopped when the effluent flowrate had reduced to about 1/3 liter per minute because of media fouling. These results indicate that the BYOW concept is extremely effective at decontaminating influent water.

The BYOW concept is a promising appropriate technology solution for densely populated developing communities. Additional research and development efforts are aimed to realize the potential of the BYOW system as open source technology for addressing public health challenges in the developing world.

For more information, please reference:

Engineers Without Borders-USA www.ewb-usa.org

Engineers Without Borders-USA Johnson Space Center Chapter www.ewb-jsc.org

Contact: ethomas@ewb-jsc.org.

BYOW system journal paper:

<https://webfiles.colorado.edu/ethomas/www/BYOWPaperJournalSubmission.pdf>

A schematic for the complete BYOW system is shown below. This figure shows the nominal flow path of the water under treatment, as well as the water used in backwash mode.

The BYOW-PUMP filtration system consists of the following components, corresponding to the numbers in Figure 1.

Table 1: BYOW system components

1. Dirty source water	9. Rapid sand filter
2. Positive displacement pump	10. Backwash inlet valve
3. Backwash throttle valve	11. Sand filter outlet valve
4. Pump recirculation port	12. UV sterilization box
5. Vacuum relief valve	13. UV light
6. Roughing filter	14. UV electronics box
7. Sand filter inlet valve	15. System start button
8. Backwash outlet valve	16. Collection tap

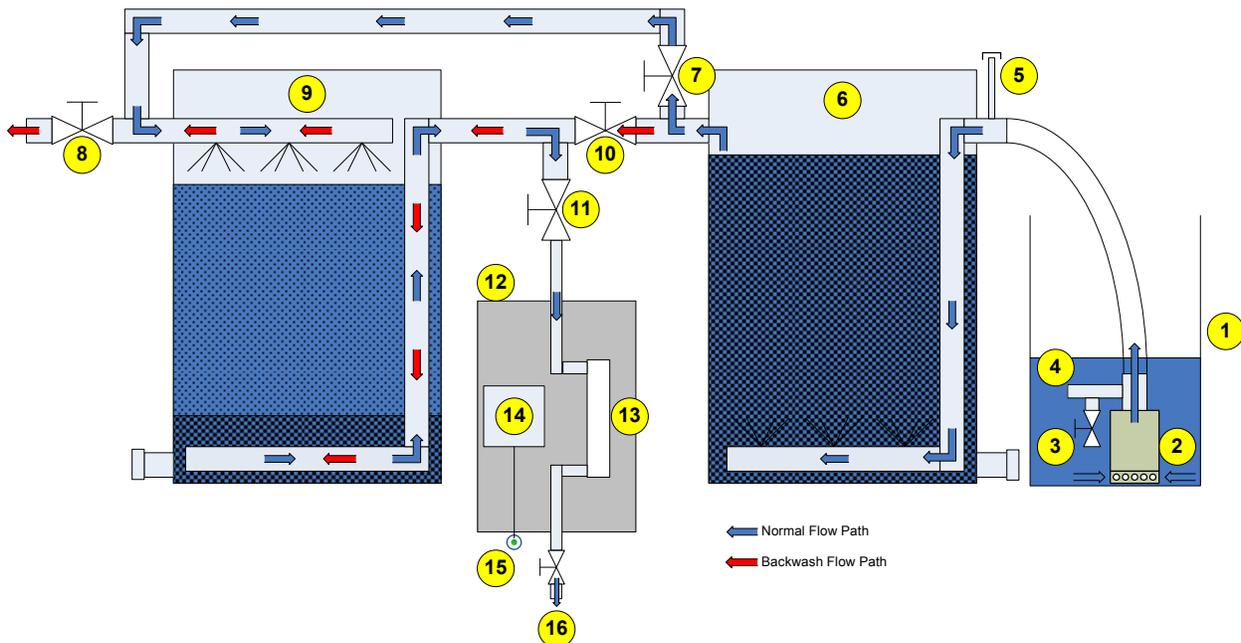


Figure 1: BYOW system schematic showing nominal water flow path in blue and backwash flow path in red

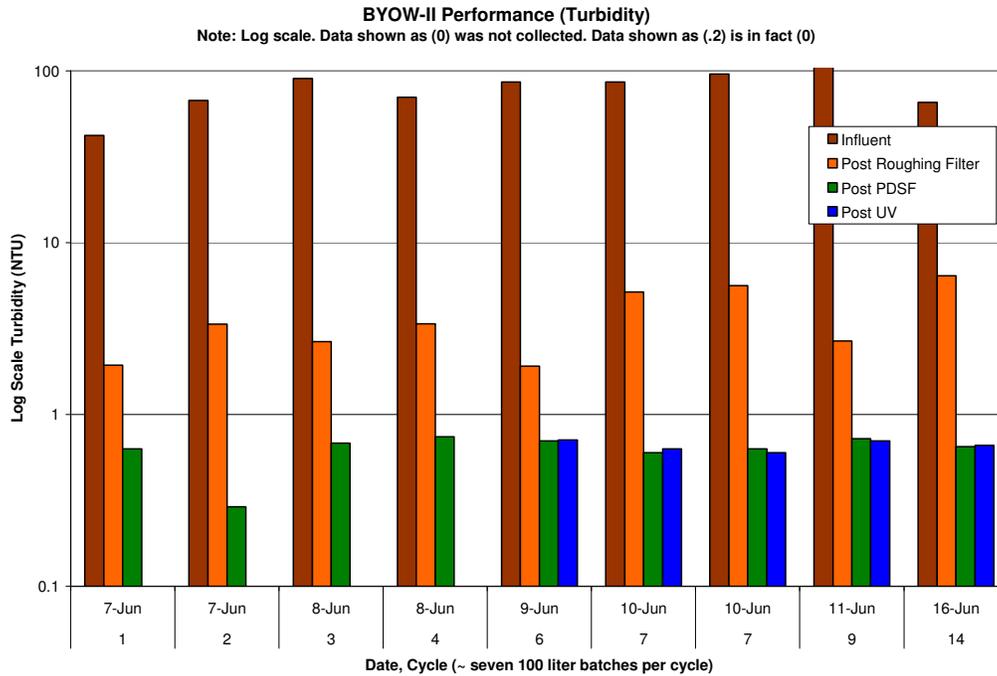


Figure 2: BYOW-PUMP Turbidity Reduction Performance

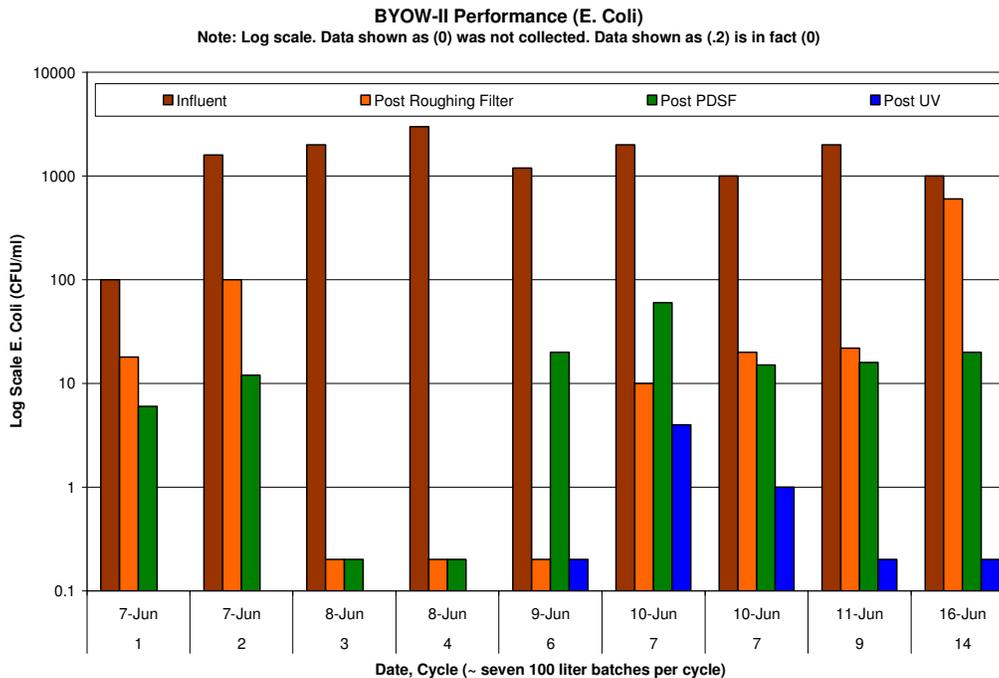


Figure 3: BYOW-PUMP Bacteria Reduction Performance

3.0 Operation Procedures

3.1 *Water Treatment*

The outlet of the pump is plumbed to a recirculation port (4), which ensures that if all the valves are closed the maximum system pressure does not exceed 5 psi (well below the drum maximum pressure limit).

The pump is placed in the source water container with the backwash throttle valve (3) open. This valve has been sized obtain maximum flow rate through the system (approximately 5 gpm) that the UV light can handle. The sand filter inlet valve (7), sand filter outlet valve (11), and UV outlet valve (16) are open. The backwash inlet valve (10), backwash outlet valve (8), and UV bypass valve (14) are closed. Pressing the system start button (15) on the UV box begins a one minute timer to warm up the UV light, at which point the pump (2) is started.

Water follows an up-flow path through the roughing filter (6) where flocculation occurs in the gravel bed to remove larger suspended particles. Water then enters the rapid sand filter (9) where smaller particles and bacteria are removed through the physical straining process. The final treatment step in the process directs the flow into the UV sterilization box (12) where the water is exposed to ultraviolet light which achieves a 99.99% reduction of bacteria, viruses, and protozoa. The clean water is collected at the collection tap (16).



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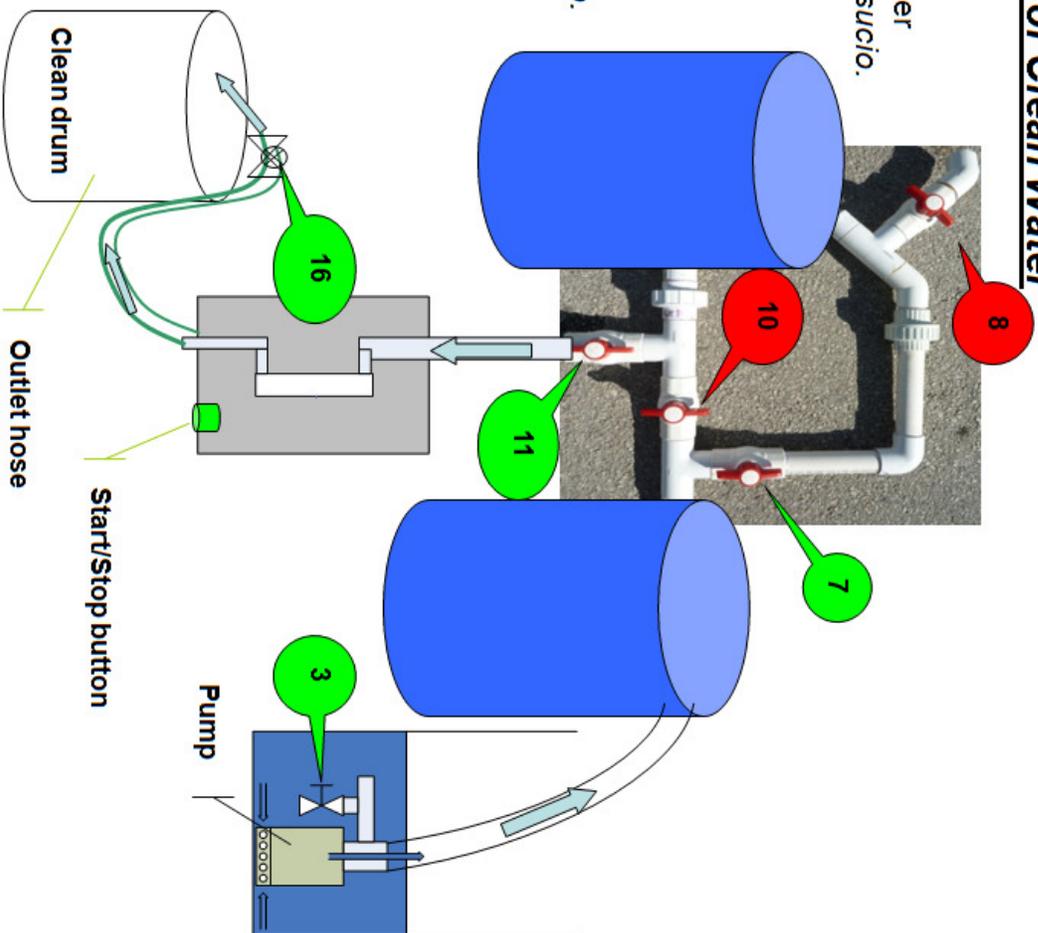
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Para Agua Limpia

For Clean Water

1. Place pump in drum with untreated water
Pone el "pump" en el "drum" con agua sucio.
2. Open valves: **3,7,11,16**
*Abre los "valves": **3,7,11,16***
3. Close valves: **10,8**
*Ferre los "valves": **10,8***
4. Place outlet hose into clean drum
Pone "outlet hose" en un "drum" lavado.
5. Push **Start/Stop** button
*Empuje **Empezar/Dejar***
6. Wait one minute for pump to start
Espera un minuto
7. Clean water will flow into clean drum
Aqua limpio va a venir entre el "drum"
8. Push **Start/Stop** button when drum is empty
*Empuje **Empezar/Dejar** cuando el "drum" esta vacio.*





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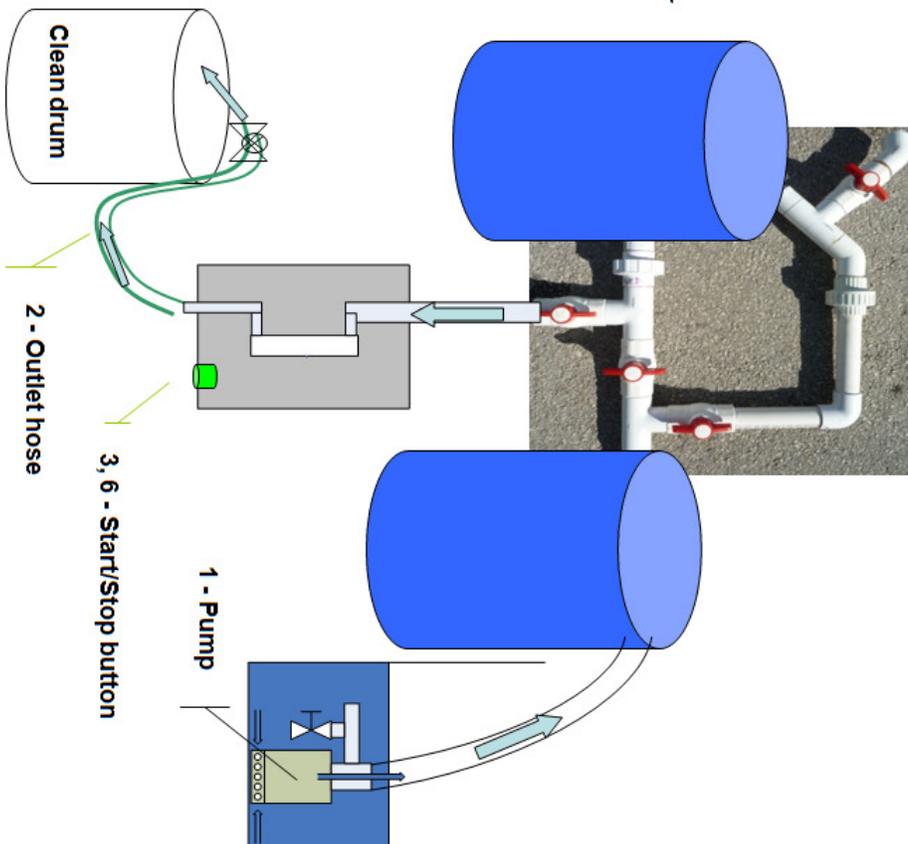
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3.2 BYOW Operational Placard / Manual de Operaciones

Cómo Limpiarse Su Agua

How To Clean Your Water

1. Pone el "pump" en el "drum" con agua sucio.
Place pump in drum with untreated water
2. Pone "desagüe manguera" en drum lipiado.
Place outlet hose into clean drum
3. Empuje **Empezar/Dejar**
Push Start/Stop button
4. Espera uno minuto para empieza el "pump."
Wait one minute for pump to start
5. Agua limpio va a venir por el "drum" limpio.
Clean water will flow into clean drum
6. Empuje **Empezar/Dejar** otra vez cuando el "drum" esta vacio.
Push Start/Stop button when drum is empty



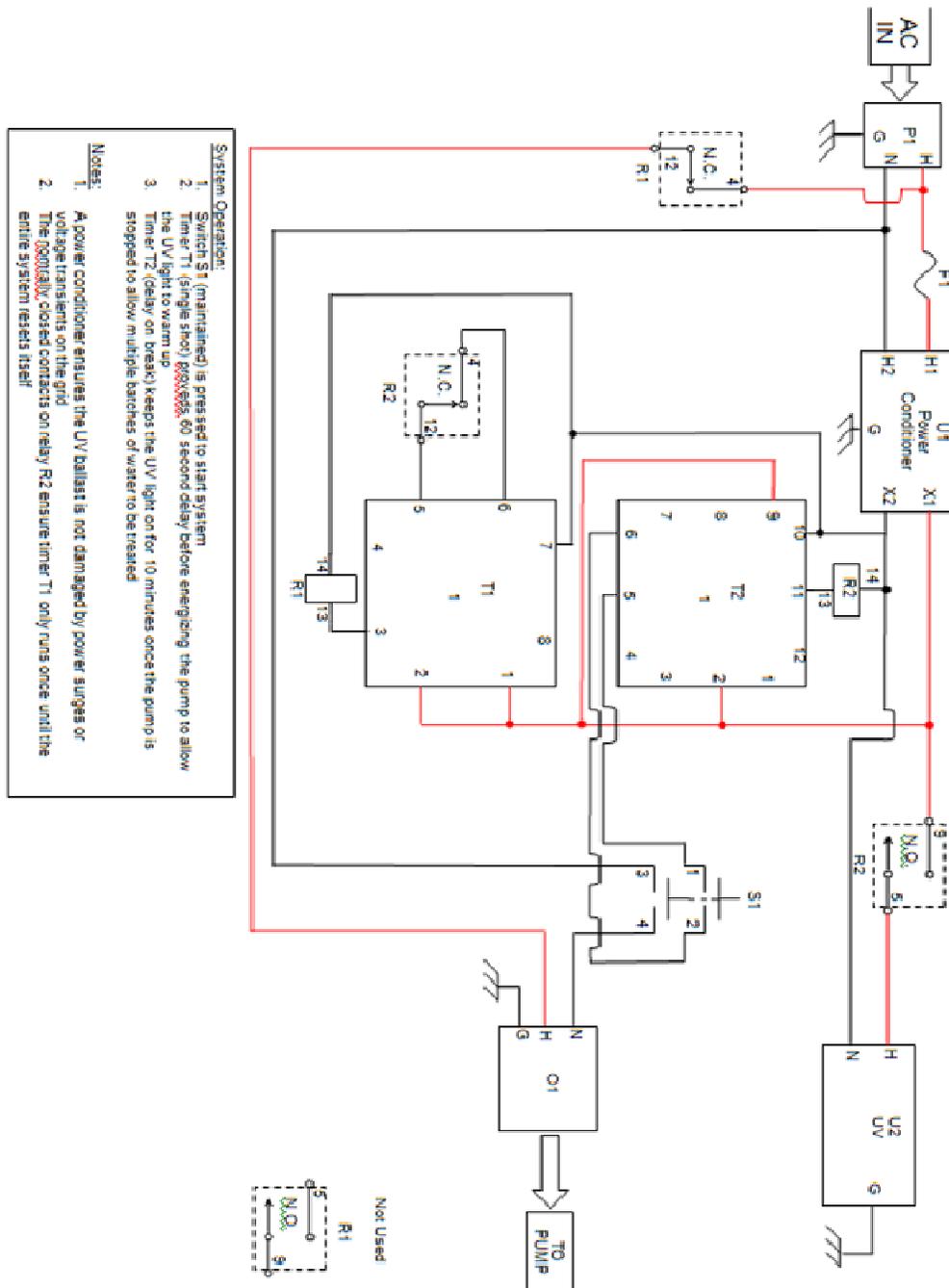


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3.3 Design of Ultraviolet light electronic circuit





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Reference Designator	Assembly	Part Description	Part Number	Quantity
P1	Socket, 3 Prong			1
O1	Outlet, 3 Prong			1
PUMP	Water Pump			1
F1	Fuse Assembly	Fuse Holder		1
		10 Amp Fuse		1
R1, R2	Relay Assembly	Relay Socket		2
		Relay		2
T1	Timer Assembly, 60 seconds	Timer Socket		1
		Timer		1
T2	Timer Assembly, 10 minutes	Timer Socket		1
		Timer		1
S1	Switch Assembly	Push Button		1
		Switch Socket		1
		Switch		2
U2	UV light Assembly	Ballast		1
		UV light		1
		UV Sleeve		1

4.0 Maintenance Procedures

4.1 Backwashing the Rapid Sand Filter

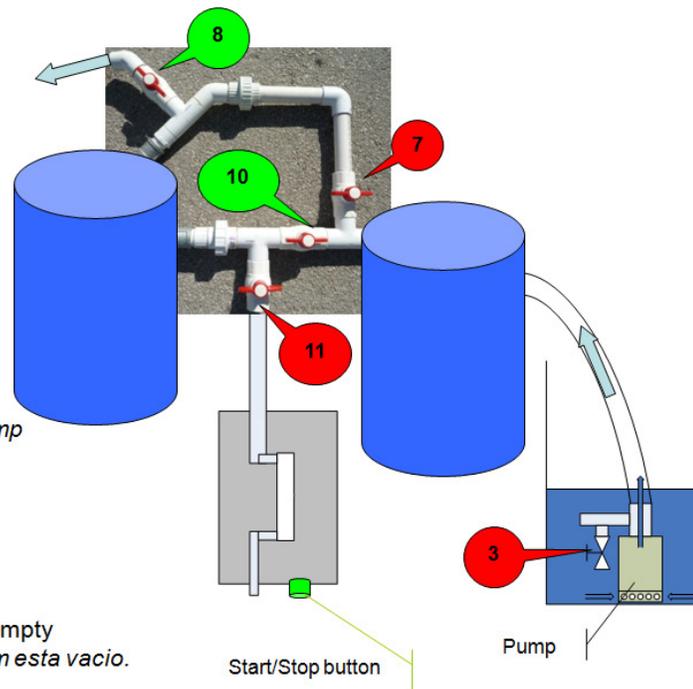
Periodic backwashing of the rapid sand filter is required to remove collected particulates and increase flow. A minimum of 50 gallons is required to adequately fluidize the filter bed and purge the system. The pressure backwash throttle valve (3) is closed to maximize flow through the system and fluidize the sand bed. The sand filter inlet valve (7) and sand filter outlet valve (11) are closed. The backwash inlet valve (10) and backwash outlet valve (8) are open. The pump (2) is turned on and allowed to run until at least 50 gallons have been pushed through the system.

Backwashing intervals are a factor of system use and source water contamination. On the conservative side we will recommend the community backwash once a month. This can be done with contaminated source water since backwashing does not rely on cleaning the sand. Bed fluidization is what removes the accumulated particulate, which only requires high pressure and high flow.

Para Estelar (casa mes)

To Backwash (Once a Month)

1. Place pump in drum with water
Pone el pump en el drum con agua
2. Close valves: **3,7,11**
Ferme valves: 3,7,11
3. Open valves: **10,8**
Abre valves: 10,8
4. Push **Start/Stop** button
Empuje Empezar/Dejar
5. Wait one minute for pump to start
Espera un minuto para empezar el pump
6. Dirty water will flow out of **Valve 8**
Agua sucio va a venir al Valve 8
7. Push **Start/Stop** button when drum is empty
Empuje Empezar/Dejar cuando el drum esta vacio.



4.2 Draining the Roughing Filter

Purpose:	Allow accumulated sediment in the bottom of the roughing filter to drain out of the system.
Frequency:	After every two backwash cycles of the rapid sand filter, or as needed
Tools:	Pipe wrench
Duration:	10 minutes

Procedure Steps

1. OPEN the roughing filter drain cap using pipe wrench.
2. Wait for the residual water and sediment to finish draining the system.
3. CLOSE the roughing filter drain cap using pipe wrench.
4. Begin to ADD water to the roughing filter.
5. PRESS the system “on” button.
6. Wait until water exits the UV box outlet valve.
7. STOP adding water to the roughing filter.

4.5 Changing the UV Light Bulb *Cambiarse la luz "UV"*

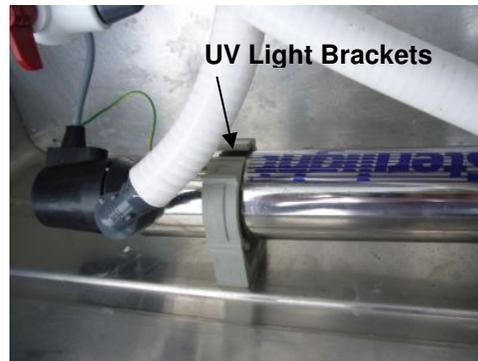
1. OPEN the UV box.

Abre la caja UV.



2. OPEN the UV light brackets.

Abre los corchete del UV.



3. RETRACT electric socket and retaining clip.

Toma enchufe eléctrico y retener clip.



4. REMOVE grounding lug nut and ground wire.

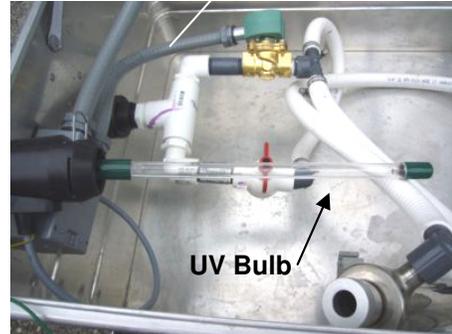
Se quita lug tuerca a tierra y el cable de tierra.

Grounding Lug Nut



5. SLIDE OUT the electric socket and UV bulb.

Diapositiva el enchufe eléctrico y bombilla UV.



6. REMOVE UV bulb.

Se quita "UV bulb".



7. INSERT new UV bulb in electronic ballast.

Pone el nuevo UV "bulb" en el "electronic ballast."

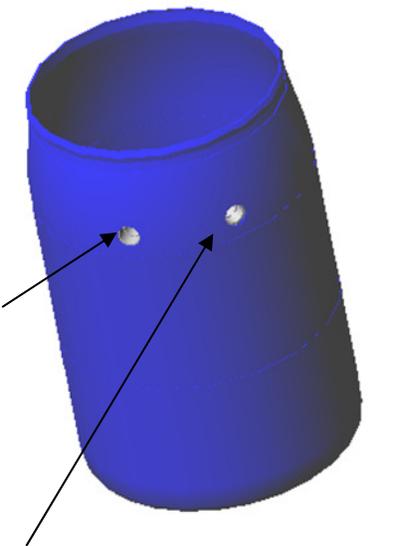


8. ASSEMBLE UV light in reverse order.

Reuna el UV luz in order reversa.

5.0 Build Procedures

5.1 Plastic Drum Sand Filter

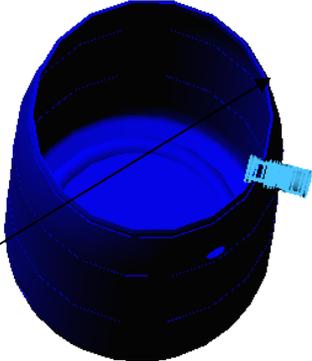
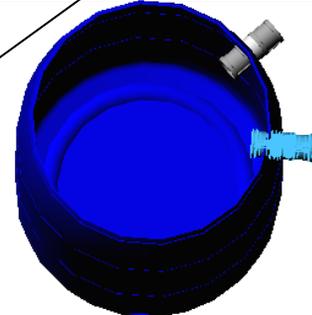
Step Number	Instructions		Rationale
<p>1 Inlet and Outlet Holes</p>	<p>1A Start with a clean drum.</p> <p>1B Remove and set aside the lid.</p> <p>1C Using a hole saw, drill a 47.75 mm (1.88 inch) diameter hole 124.5 mm (4.9 inch) down from the top lip of the Drum.</p> <p>1D Drill a second same diameter hole at the same distance down and 45 Degrees from the first hole 470 mm (18.5 inch) from center to center measured on the surface of the drum.</p>		<p>Hole Placement: The holes are placed low enough so that the internal piping does not interfere with the lid and does not overlap the curved part of the drum so the seal has a singly curved surface to seal against. The hole also needs to be as high as possible so that during back flush sand is not washed out of the water distribution cross arm.</p> <p>Hole Size: The hole size was chosen so that the fitting to be used just fits inside the hole so that the gasket can seal the well and there is drum wall for the fitting to tighten down against.</p>



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<p>2 Placing the First Bulkhead Fitting</p>	<p>2A Using the bulkhead installation procedure, place a bulkhead fitting into one of the drilled holes.</p>		
<p>3 Placing the Second Bulkhead Fitting</p>	<p>3 A Using the bulkhead installation procedure, place a bulkhead fitting into the second drilled holes</p>		
<p>4 Placing the Outlet ELL Fitting</p>	<p>4A Thread a MPT to slip transition fitting into the outlet bulkhead fitting.</p> <p>4B Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and place it into the slip fitting of the transition</p>		



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	<p>fitting. DO NOT glue the piece in place at this time.</p> <p>4B Place a 90 degree ELL fitting over the short length of pipe with the outlet pointed down. DO NOT glue the piece in place at this time</p>		
<p>5 Placing the Outlet Union Fitting</p>	<p>5A Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and place it into the slip fitting of the ELL as shown.</p> <p>5B Dry fit a completely assembled Union onto the connector pipe at the bottom of the ELL. Place the fitting so that the side WITHOUT the “O” ring is fitted to the ELL.</p>		



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<p>6 Building the Collection Cross Arm Sub- assembly</p>	<p>6A Start with a 38 mm cross (1.5 inch)</p> <p>6B Cut three lengths of 38 mm PVC pipe to a length of 216 mm (8.5 inch) and dry assemble them (with out glue at this time) into the partial cross as shown</p> <p>6C Dry assemble caps to the three lengths of pipe.</p> <p>6D Verify the fit of the partial cross into the drum. With the partial cross at the center of the drum. The partial cross should be supported on the end cap sides and at the center cross..The partial cross should sit flush on the bottom of the drum.</p>		<p>The collection cross arm length should be as long as possible to provide for the best distribution of flow. This length depends on the diameter of the drum that is used.</p> <p>The cross arm should not be so long that the ends ride up on the curved edge of the drum so that the cross is only supported at the ends. This is necessary because rocks and sand are going to be placed on top of the cross and it will break under the weight if it is only supported on the corners of the end caps.</p> <p>Support should be along the edges here and here and not on the corner of the end cap because the cross arms are too long and cause the ends to ride up on this curve.</p>
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7
Connect
the
Collection
Cross Arm
Subassem-
bly to the
outlet
Union

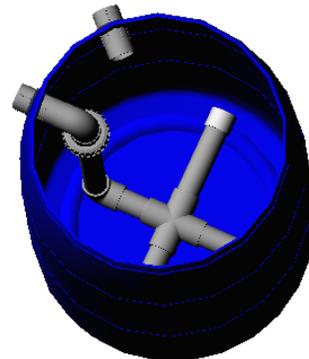
7A Dry fit a 90 degree ELL to a length of 38 mm (1.5 inch) pipe and place it in the drum vertically and mark the length to fit inside the “O” ring side of the Union. Cut the pipe to fit. (545 mm (21.5 inch) is the approximate size). Dry fit the pipe to the Union resulting in the configuration shown.



7B Measure and cut a length of 38 mm (1.5 inch) pipe to fit into the ELL and the cross so that the cross is in the middle of the bottom of the drum when the pipe from the top is vertical.



7C Dry fit this pipe into the ELL and cross to end up with the configuration shown.





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<p>8 Bond the Collection Cross Sub Assembly together</p>	<p>8A Disconnect the Union and remove the dry fitted Collection Cross Sub assembly as shown.</p> <p>8B Disconnect the parts of the Collection Cross sub assembly one by one. At each joint clean the joint for bonding, and then bond the joint together using primer and PVC glue. There are 11 joints. Ten are shown in the exploded view. The last joint is at the Union to the top of the upright pipe. .</p>		<p>Make sure the upright pipe remains vertical when the cross is flat on a horizontal surface</p>
<p>9 Drill the collection holes.</p>	<p>9A Drill a 6.35 mm (1/4 inch) VERTICLE hole in the middle of the cross only through the top wall of the cross.</p> <p>9B Drill a 6.35 mm (1/4 inch) VERTICLE hole at the intersection of</p>		



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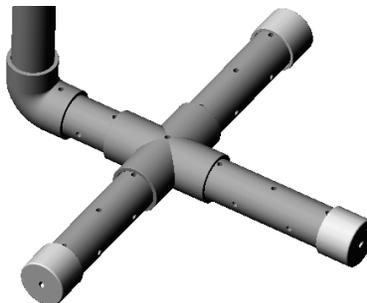
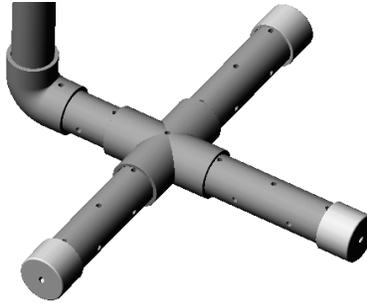
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the cross and
the pipe in 4
places only
through the top
wall of the pipe.

9C Drill a 6.35
mm (1/4 inch)
VERTICLE hole
at the
intersection of
the End Caps
and the pipe in
3 places only
through the top
wall of the pipe.

9D Drill a 6.35
mm (1/4 inch)
VERTICLE hole
in the pipe
midway
between the
holes at the
intersection of
the End Caps
and the Cross
in 3 places only
through the top
wall of the pipe.

9E Drill a 6.35
mm (1/4 inch)
VERTICLE hole
in The ELL at
the same
distance apart
as the other
holes. 1 places
only through
the top wall of
the ELL and the
pipe.





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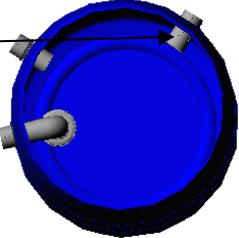
	<p>9F Drill a 6.35 mm (1/4 inch) HORIZONTAL hole in each pipe midway between the vertical holes. 7 places through both walls of the pipe.</p> <p>9G Drill a 6.35 mm (1/4 inch) HORIZONTAL hole in each End cap at a 45 deg angle from the vertical. 3 places through one wall of the end cap.</p>		<p>45 deg</p>
<p>10 Bond the outlet ELL and Upper part of the Union</p>	<p>10A Disconnect the parts of the outlet ELL and upper part of the Union one by one.</p> <p>10B At each joint clean the joint for bonding, and then bond the joint together using primer and PVC glue. There are 4 joints. Be sure the Union locking collar is on before the</p>		<p>These joints must be made in such a manner that the vertical length remains the same as the dry fitted assembly so that the Collection Cross sub assembly will fit between the bottom of the upper part of the Union and the bottom of the drum.</p>



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	<p>drain. (A side location is shown)</p> <p>11E Using the bulkhead installation procedure, install a bulkhead fitting into the drain hole.</p>		<p>bottom of the drum.</p> <p>CAUTION: This operation requires working with a person's head inside the drum. This sets up a confined space situation that requires the person to work quickly so there is no build up of carbon dioxide in the confined space.</p>
<p>12 Place the Sand Retention Screen</p>	<p>12A Wrap the end of the inside of the bulkhead fitting with screen.</p> <p>12B Place a band clamp over the screen and tighten it so the screen is held firmly in place.</p>		<p>CAUTION: This operation requires working with a person's head inside the drum. This sets up a confined space situation that requires the person to work quickly so there is no build up of carbon dioxide in the confined space.</p> <p>The screen prevents the sand in the system from being washed out of the drum when the drain is opened. If this screen is too large sand will be lost anyway. If that happens, stop the drain process and place a cloth on the ground to catch the sand. Failure to recapture the sand will mean it must be re-sieved to get the proper grain size for the filter to operate.</p>
<p>13 Place the outside Drain fitting Plug</p>	<p>13A Cut a length of threaded 38 mm (1.5 inch) pipe of sufficient length to lead outside</p>		<p>A short piece of pipe is shown.</p>



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of any building or away from any foundation and thread it into the outside of the bulkhead fitting.

13B Thread a Female threaded cap onto the male threads of the Transition fitting so that it is tight enough to hold water.



Placing the cap on the drain fitting tends to tighten the bulkhead fitting. Use caution when removing the fitting as this action tends to loosen the bulkhead fitting. A wrench should be placed on the Transition fitting so that the bulkhead fitting is not loosened when the cap is removed.

14
Place the inside inlet fittings

14A Thread a MPT to Slip transition piece into the inside of the inlet bulkhead fitting.

14B Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place it into the slip fitting. Bond the joint together using primer and PVC glue.

14B Place the

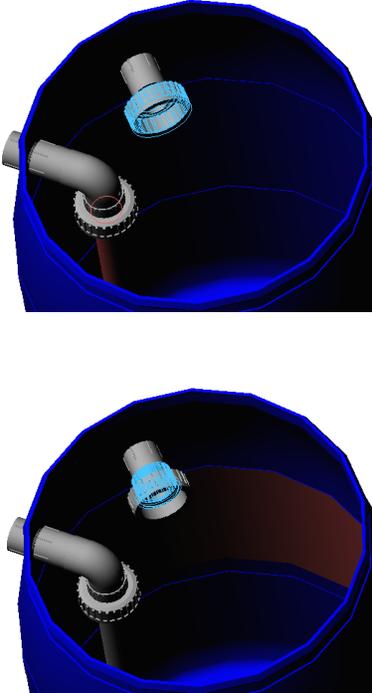
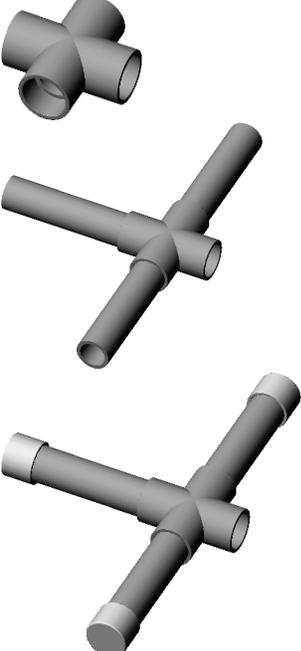




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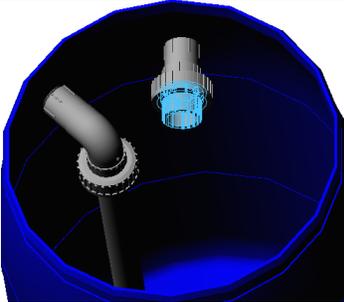
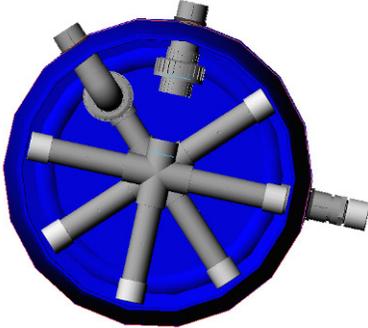
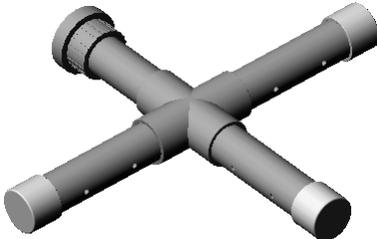
	<p>locking collar or the Union over the female side of the remaining gray PVC electrical conduit 38.1 mm (1.5 inch) bulkhead fitting.</p> <p>14C Bond the unthreaded part of the Union fitting to the 2 inch connector using primer and PVC glue.</p>		
<p>15 Building the Distribution Cross Arm Subassembly</p>	<p>15A Start with a 38 mm cross (1.5 inch)</p> <p>15B Cut three lengths of 38 mm PVC pipe to a length of 216 mm (8.5 inch) and dry assemble them (with out glue at this time) into the partial cross as shown</p> <p>15C Dry assemble caps</p>		<p>The collection cross arm length should be as long as possible to provide for the best distribution of flow. This length depends on the diameter of the drum that is used.</p>



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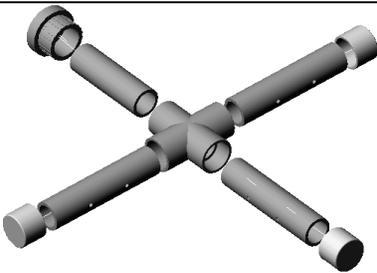
	to the three lengths of pipe.		
16 Measure the length of the Distribution Cross Arm Subassembly Connecting Pipe	<p>16A Connect the threaded part of the Union to the mating part of the Union that is mounted on the inlet line.</p> <p>16B Have an assistant hold the Dry assembled Cross Arm piece assembled in step 15 so that it lines up with the Union and is centered in the drum</p> <p>16C Measure the length of pipe needed to connect the slip fitting in the cross in the distribution subassembly with the slip fitting in the unthreaded part of the Union</p> <p>16D Cut a length of pipe to the measured</p>	  	



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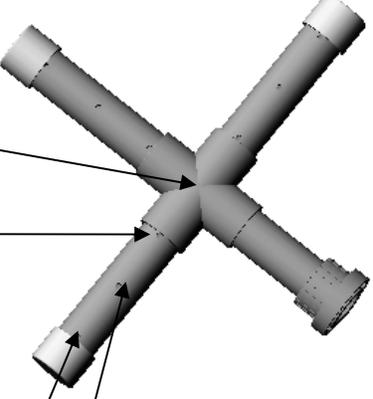
	dimension, remove the unthreaded part of the Union and dry fit the Distribution Cross Arm Subassembly together.		
17	17A Disconnect the parts of the Collection Cross sub assembly one by one. At each joint clean the joint for bonding, and then bond the joint together using primer and PVC glue. There are 8 joints.		
18 Drill the inlet holes	18A Drill a 6.35 mm (1/4 inch) VERTICAL hole in the middle of		The distribution cross only needs holes on what will be the bottom of the cross. Since the cross can easily be turned over



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<p>in the inlet cross assembly</p>	<p>the cross only through the top wall of the cross.</p> <p>18B Drill a 6.35 mm (1/4 inch) VERTICAL hole at the intersection of the cross and the pipe in 4 places only through the top wall of the pipe.</p> <p>18C Drill a 6.35 mm (1/4 inch) VERTICAL hole at the intersection of the End Caps and the pipe in 3 places only through the top wall of the pipe.</p> <p>18D Drill a 6.35 mm (1/4 inch) VERTICAL hole in the pipe midway between the holes at the intersection of the End Caps and the Cross in 3 places only through the top wall of the pipe..</p> <p>18E Drill a 6.35</p>		<p>upon assembly, the directions for drilling are given as if the cross is laying on a flat surface.</p>
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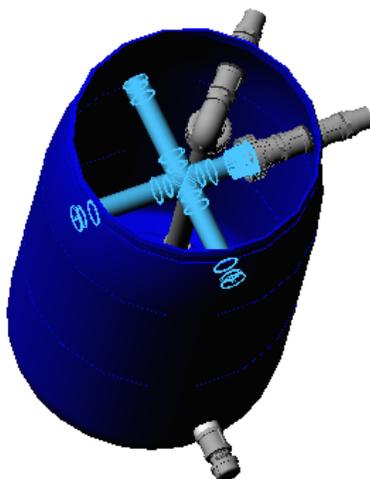
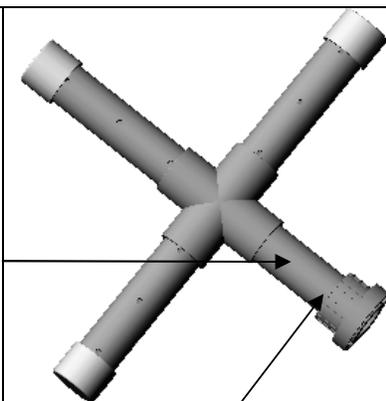
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mm (1/4 inch)
VERTICAL hole
in the pipe
midway
between the
intersection of
the Union and
the Cross in 1
places only
through the top
wall of the pipe.

18F Drill a 6.35
mm (1/4 inch)
VERTICAL hole
in the pipe at
intersection of
the Union and
the pipe in 1
places only
through the top
wall of the
pipe..

18G Place the
Distribution
cross into the
fast sand filter
attaching it with
the Union
fitting.





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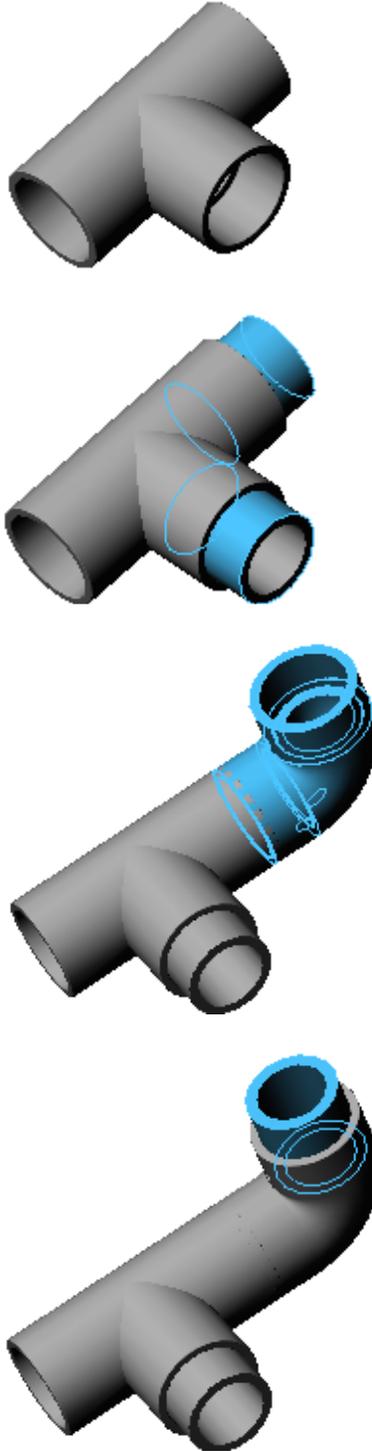
19 Build the Inlet Valve Sub- assembly

19A Start with a 38 mm (1.5 inch) “T” fitting.

19B Cut two 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place it into the slip fitting of the “T” as shown. Bond the two joints together using primer and PVC glue.

19 C Dry fit a 90 degree ELL fitting to the long side of the “T” fitting as shown

19D Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place it into the slip fitting of the ELL as shown. Bond the joint together using primer and PVC glue. Do Not bond the ELL to the long side of the “T” at this



The Ell fitting is left un bonded at the “T: fitting so that there is flexibility in arranging the final position of the valves during the final assembly of the entire system.



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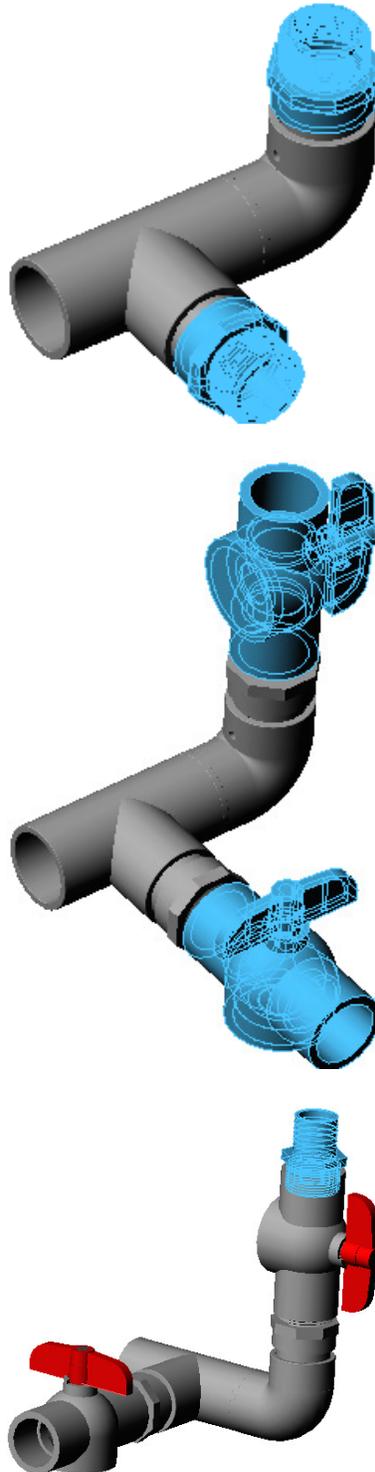
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time.

19E Place two slip joint to male pipe thread (MPT) transitions fittings in place as shown and bond them with primer and PVC glue.

19F Thread two 38 mm (1.5 inch) Ball Valves onto the MPT side of the transition fitting.

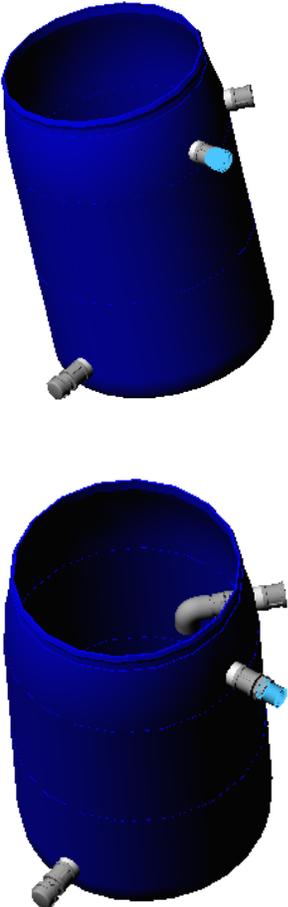




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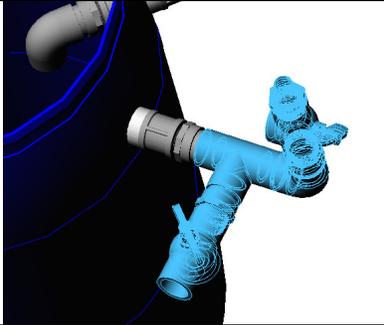
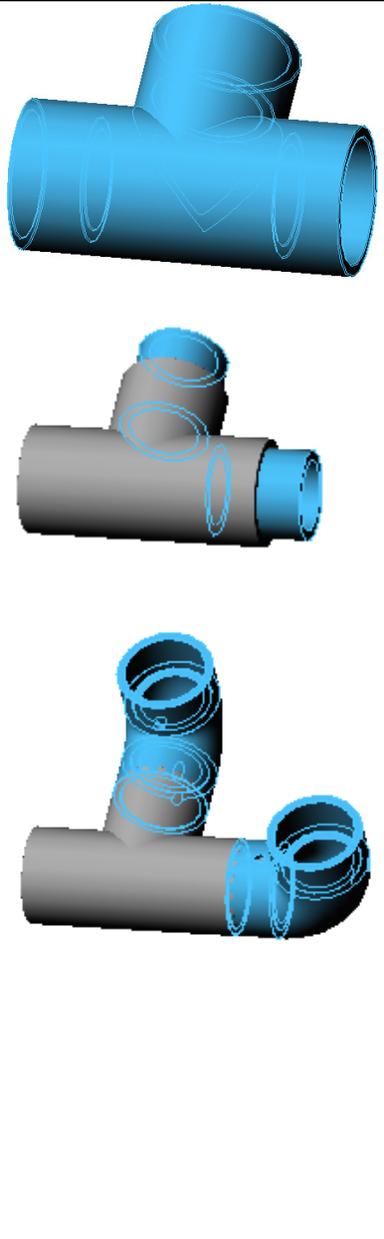
	<p>19G Thread a 38 mm (1.5 inch) MPT to 38 mm (1.5 inch) plastic hose barb fitting in the inlet valve as shown</p>		
<p>20 Assemble the Inlet Valve Subassembly to the drum</p>	<p>20A Thread a MPT to Slip transition fitting into the outside of the inlet bulkhead fitting.</p> <p>20B Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place it into the slip fitting of the inlet bulkhead fitting as shown. Bond the joint together using primer and PVC glue.</p> <p>20C Dry fit the Inlet Valve Subassembly to the inlet bulkhead fitting.</p>		<p>The Inlet Valve Subassembly is left un bonded at the bulkhead fitting so that there is flexibility in arranging the final position of the valves during the final assembly of the entire system</p>



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	<p>Make sure the previous joint is dry so that inadvertent bonding does not occur.</p>		
<p>21 Build the Outlet Valve Subassembly</p>	<p>21A Start with a 38 mm (1.5 inch) “T” fitting.</p> <p>21B Cut two 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place them into the slip fittings of the “T” as shown. Bond the two joints together using primer and PVC glue</p> <p>21C Install two ELL fittings as shown. Bond the two joints together using primer and PVC glue</p> <p>21D Cut two 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for</p>		

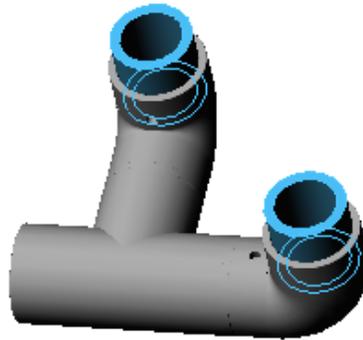


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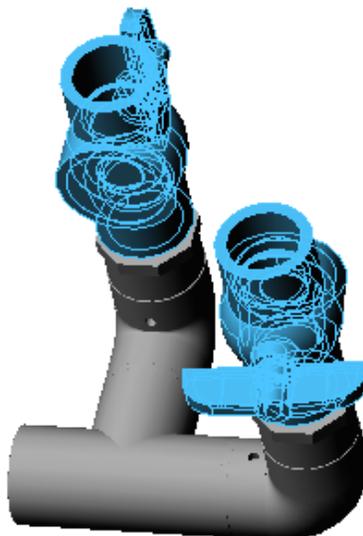
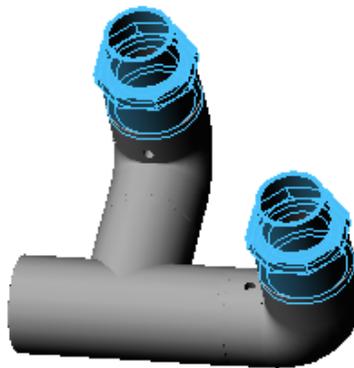
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bonding, Place them into the slip fittings of the two ELL fittings as shown. Bond the two joints together using primer and PVC glue



21E Install two slip fitting to 38 mm (1.5 inch) male pipe thread (MPT) transition fittings at the ELL fittings as shown. Bond the joint together using primer and PVC glue





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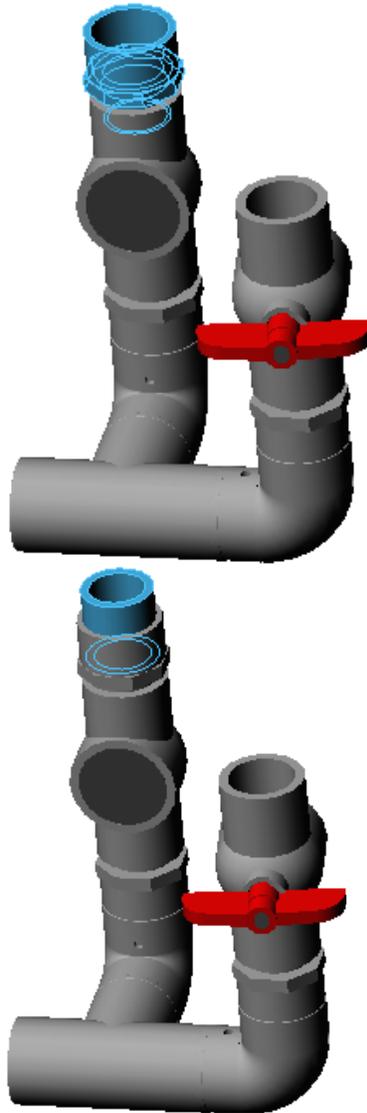
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21F Thread two 38 mm (1.5 inch) ball valves onto the MPT as shown.

21G Thread one slip fitting to 38 mm (1.5 inch) male pipe thread (MPT) transition fitting to the outlet valve as shown.

21H Cut one 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place it into the slip fittings of the 38 mm (1.5 inch) male pipe thread (MPT) transition fitting as shown. Bond the joint together using primer and PVC glue



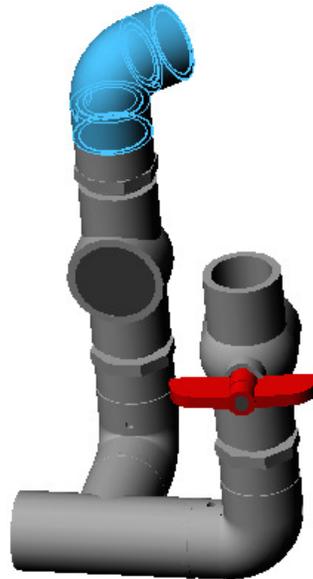


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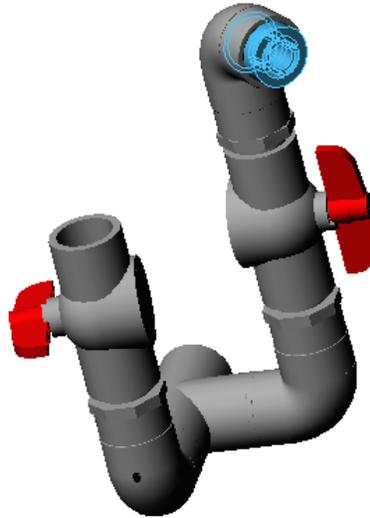
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21 I Place an ELL fitting onto the outlet valve as shown. Do not bond the fitting at this time.



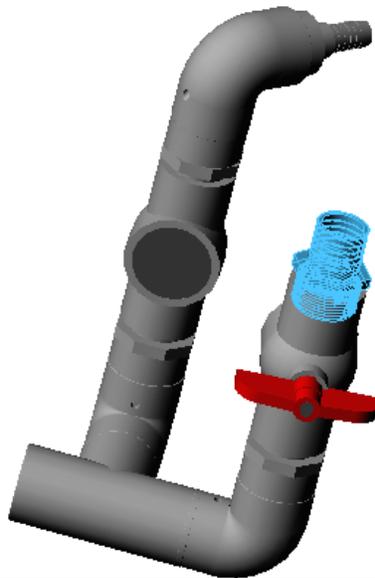
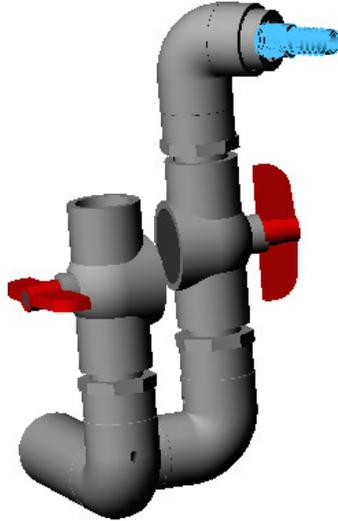
The outlet ELL is left unbonded at this time to allow flexibility in arranging the final position of the outlet during the final assembly of the entire system

21J Install a slip fitting to 19 mm (3/4 inch) female pipe thread (FPT) transition fitting at the ELL fittings as shown. Bond the joint together using primer and PVC glue



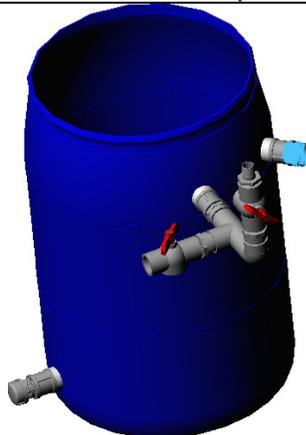
21K Thread a 19 mm (3/4 inch) to plastic hose barb fitting in the transition fitting as shown.

21L Thread a
38 mm (1.5
inch) MPT to 38
mm (1.5 inch)
plastic hose
barb fitting in
the backwash
inlet valve as
shown



22
Assemble
the Outlet
Valve
Subassem-
bly to the
drum

22A Thread a
MPT to Slip
transition fitting
into the outlet
bulkhead fitting.



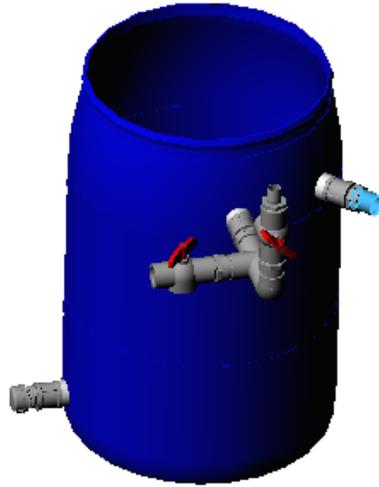


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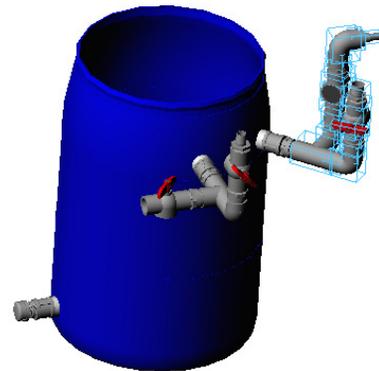
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22B Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place it into the slip fitting of the inlet gray bulkhead fitting as shown. Bond the joint together using primer and PVC glue.



22B Dry fit the Outlet Valve Subassembly to the outlet bulkhead fitting. Make sure the previous joint is dry so that inadvertent bonding does not occur.



The Outlet Valve Subassembly is left un bonded at the bulkhead fitting so that there is flexibility in arranging the final position of the valves during the final assembly of the entire system

23

23A Retrieve the lid set aside in step 1B.



23B Drill a $\frac{3}{4}$ inch hole in the center of the lid to just match



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the diameter of a 19 mm (3/4 inch) piece of threaded pipe.

23C Place a 19 mm (3/4 inch) “O” Ring on a 25 mm (1 inch) length of threaded pipe.

23D Place the pipe in the central hole of the lid with the “O” ring on the inside of the lid

23E Thread the female side of an electrical conduit bulkhead fitting (or a threaded nut with a washer) to the inside of the pipe until it just touches the “O” ring.



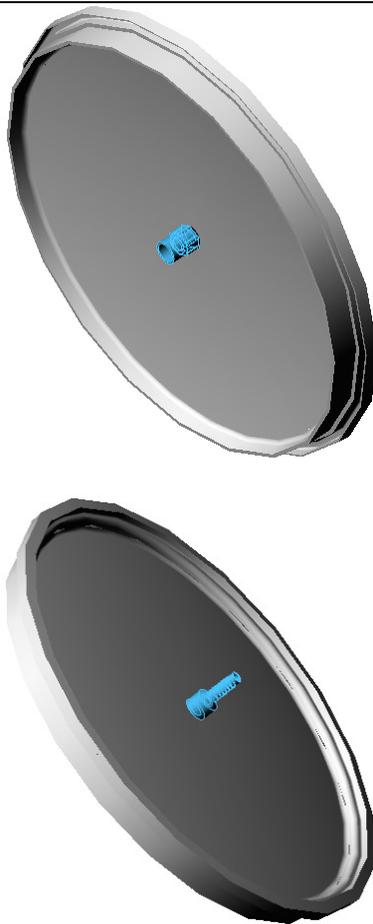


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23F Thread a female XX mm (3/4 inch) to tube fitting transition piece to the outside threads of the threaded pipe. Tighten to squeeze the “O” ring and form a water tight seal.



24 Mount the lid on the drum and set the assembly aside for installation into the larger system

24A Place the lid on the drum.



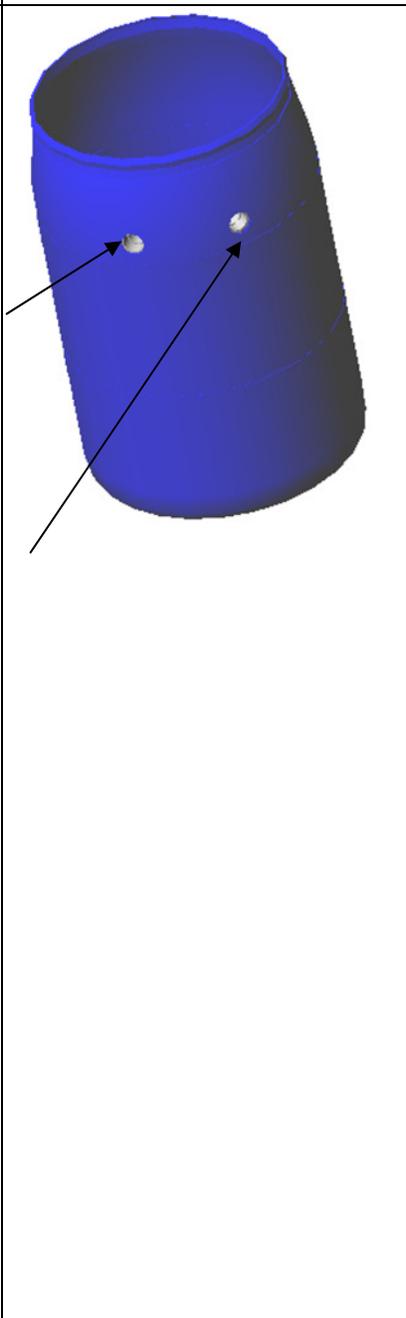
24B Place the locking ring on the drum and lid but do not lock it in place

at this time.

24C Set the assembly aside until the foundation is ready and it can be installed in the larger system.



Plastic Drum Gravel Filter

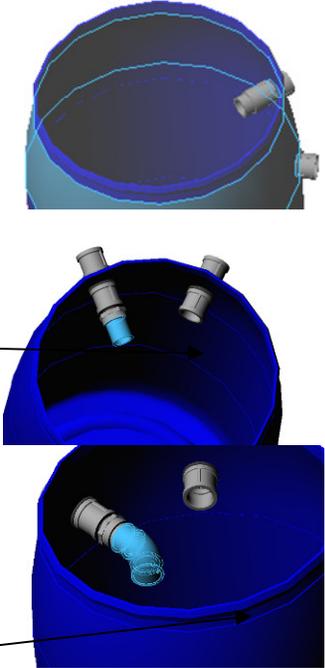
Step Number	Instructions		Rationale
<p>1 Inlet and Outlet Holes</p>	<p>1A Start with a clean drum.</p> <p>1B Remove and set aside the lid.</p> <p>1C Using a hole saw, drill a 47.75 mm (1.88 inch) diameter hole 124.5 mm (4.9 inch) down from the top lip of the Drum.</p> <p>1D Drill a second same diameter hole at the same distance down and 45 Degrees from the first hole 470 mm (18.5 inch) from center to center measured on the surface of the drum.</p>		<p>Hole Height Placement: The holes are placed low enough so that the internal piping does not interfere with the lid and does not overlap the curved part of the drum so the seal has a singly curved surface to seal against. The hole also needs to be as high as possible so that during back flush sand is not washed out of the water distribution cross arm.</p> <p>Hole Clocking Placement: The holes for the roughing filter need to be clocked so that one is going to be at a convenient place to pour a bucket of water. The second is ideally clocked at 45 degrees for the best distribution of water flow within the filter. But local conditions could change this within the limit of not having the outlet interfere with the inlet piping. The criteria is that the outlet must be directly on the side toward the backwash tank.</p> <p>Hole Size: The hole size was chosen so that the fitting to be used just fits inside the hole so that the gasket can seal the well and there is drum wall for the fitting to tighten down against.</p>



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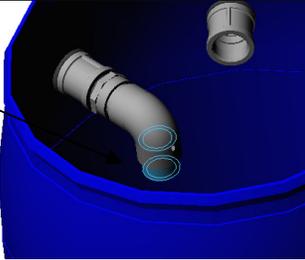
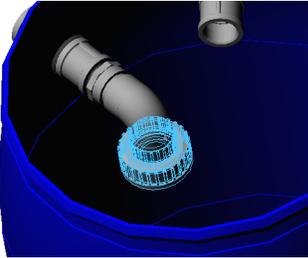
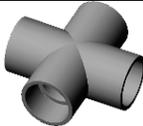
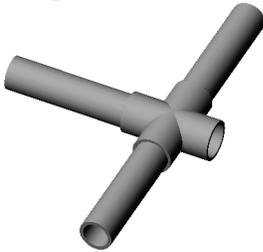
<p>2 Placing the First Bulkhead Fitting</p>	<p>2A Using the bulkhead installation procedure place a bulkhead fitting into one of the holes.</p>		
<p>3 Placing the Second Bulkhead Fitting</p>	<p>3A Using the bulkhead installation procedure place a bulkhead fitting into the other hole.</p>		
<p>4 Placing the Outlet ELL Fitting</p>	<p>4A Thread a slip to MPT transition into the inner side of the outlet bulkhead</p> <p>4B Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and place it into the transition fitting. DO NOT glue the piece in place at this time.</p> <p>4C Place a 90 degree ELL fitting over the short length of</p>		



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	pipe with the outlet pointed down. DO NOT glue the piece in place at this time		
5 Placing the Outlet Union Fitting	<p>5A Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and place it into the slip fitting of the ELL as shown.</p> <p>5B Dry fit a completely assembled Union onto the connector pipe at the bottom of the ELL. Place the fitting so that the side WITHOUT the “O” ring is fitted to the ELL.</p>	 	
6 Building the Collection Cross Arm Subassembly	<p>6A Start with a 38 mm cross (1.5 inch)</p> <p>6B Cut three lengths of 38 mm PVC pipe to a length of 216 mm (8.5 inch) and dry assemble them (with out glue at this time) into</p>	 	<p>The collection cross arm length should be as long as possible to provide for the best distribution of flow. This length depends on the diameter of the drum that is used.</p> <p>The cross arm should not be so long that the ends ride up on the curved edge of the drum so</p>



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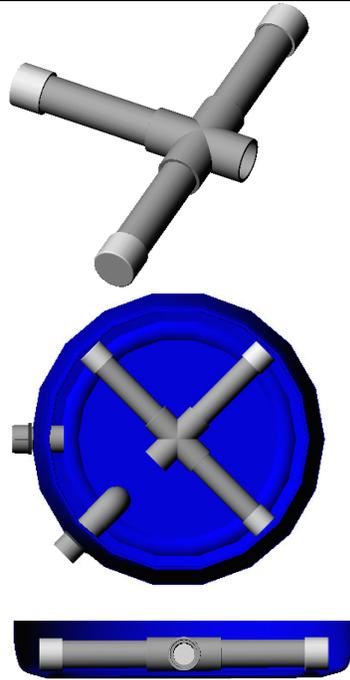
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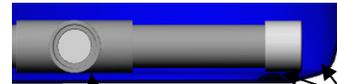
the partial cross as shown

6C Dry assemble caps to the three lengths of pipe.

6D Verify the fit of the partial cross into the drum. With the partial cross at the center of the drum, the partial cross should be supported on the end cap sides and at the center cross. The end caps should not ride up on the corner of the bottom of the drum so that the finished cross would be supported only on its ends.



that the cross is only supported at the ends. This is necessary because rocks and sand are going to be placed on top of the cross and it will break under the weight if it is only supported on the corners of the end caps.

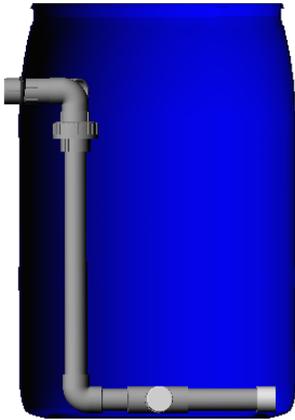
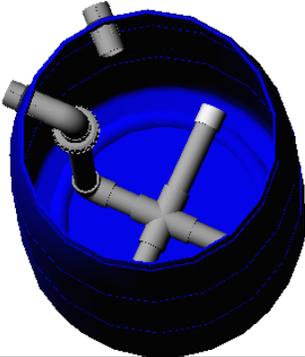
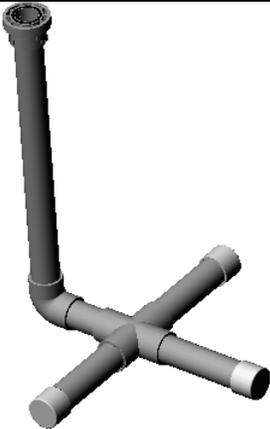


Support should be along the edges here and here and not on the corner of the end cap because the cross arms are too long and cause the ends to ride up on this curve.

7
Connect the Collection Cross Arm Subassembly to the outlet Union

7A Dry fit a 90 degree ELL to a length of 38 mm (1.5 inch) pipe and place it in the drum vertically and mark the length to fit inside the "O" ring side of the Union. Cut the pipe to fit.



	<p>(545 mm (21.5 inch) is the approximate size). Dry fit the pipe to the Union resulting in the configuration shown.</p> <p>7B Measure and cut a length of 38 mm (1.5 inch) pipe to fit into the ELL and the cross so that the cross is in the middle of the bottom of the drum when the pipe from the top is vertical.</p> <p>7C Dry fit this pipe into the ELL and cross to end up the configuration shown.</p>		
<p>8 Bond the Collection Cross Sub Assembly together</p>	<p>8A Disconnect the Union and remove the dry fitted Collection Cross Sub assembly as shown.</p> <p>8B Disconnect the parts of the Collection Cross sub</p>		<p>Make sure the upright pipe remains vertical when the cross is flat on a horizontal surface</p>

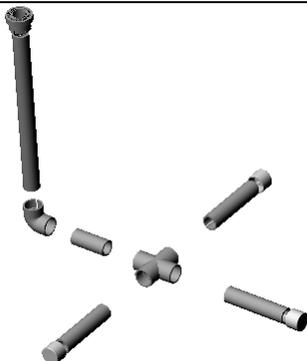


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assembly one by one. At each joint clean the joint for bonding, and then bond the joint together using primer and PVC glue. There are 11 joints. Ten are shown in the exploded view. The last joint is at the Union to the top of the upright pipe. .

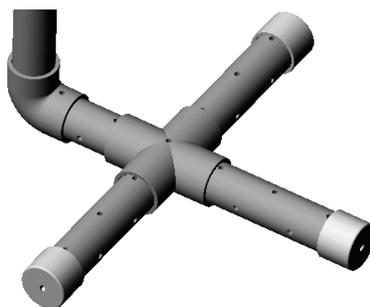
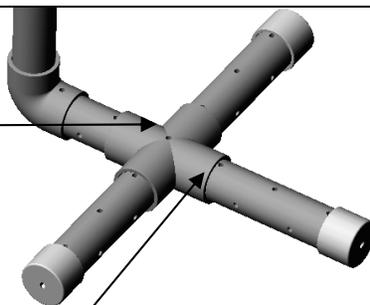


9
Drill the
collection
holes.

9A Drill a 6.35 mm (1/4 inch) VERTICLE hole in the middle of the cross only through the top wall of the cross.

9B Drill a 6.35 mm (1/4 inch) VERTICLE hole at the intersection of the cross and the pipe in 4 places only through the top wall of the pipe.

9C Drill a 6.35 mm (1/4 inch) VERTICLE hole at the intersection of the End Caps





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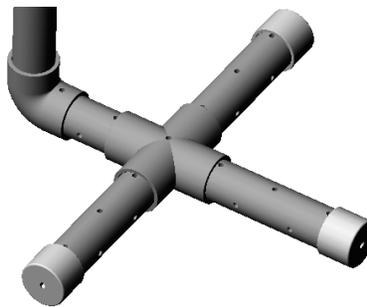
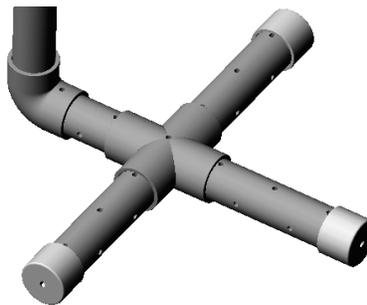
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and the pipe in 3 places only through the top wall of the pipe.

9D Drill a 6.35 mm (1/4 inch) VERTICLE hole in the pipe midway between the holes at the intersection of the End Caps and the Cross in 3 places only through the top wall of the pipe.

9E Drill a 6.35 mm (1/4 inch) VERTICLE hole in The ELL at the same distance apart as the other holes. 1 places only through the top wall of the ELL and the pipe.

9F Drill a 6.35 mm (1/4 inch) HORIZONTAL hole in each pipe midway between the vertical holes. 7 places through both walls of the pipe.

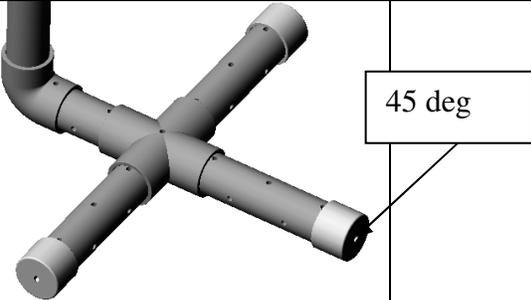
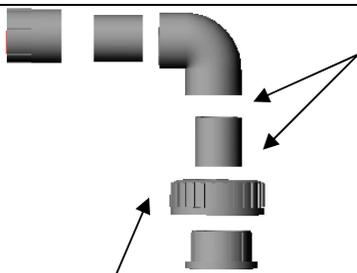
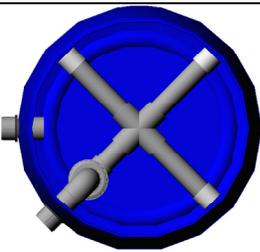




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	<p>9G Drill a 6.35 mm (1/4 inch) HORIZONTAL hole in each End cap at a 45 deg angle from the vertical. 3 places through one wall of the end cap.</p>		
<p>10 Bond the outlet ELL and Upper part of the Union</p>	<p>10A Disconnect the parts of the outlet ELL and upper part of the Union one by one.</p> <p>10B At each joint clean the joint for bonding, and then bond the joint together using primer and PVC glue. There are 4 joints. Be sure the Union locking collar is on before the Union joint is bonded.</p>		<p>These joints must be made in such a manner that the vertical length remains the same as the dry fitted assembly so that the Collection Cross sub assembly will fit between the bottom of the upper part of the Union and the bottom of the drum.</p>
<p>11 Place the Drain Bulkhead Fitting</p>	<p>11A Replace the Collection Cross sub assembly and connect it to the Union.</p> <p>11B Select a place for the drum drain that</p>		<p>The purpose of the Drum drain is to allow the water to be drained out of the drum so that it can be moved or maintained. This is an operation that does not take place often. When it does need to be done, the drain needs to be located so that it can be reached and so that a cloth can be spread</p>



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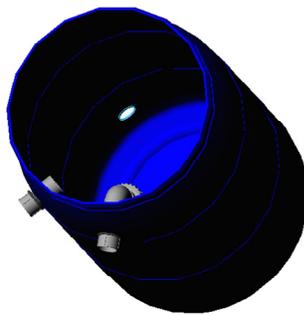
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does not interfere with the Collection Cross sub assembly. The drain can be in the side of the drum or in the bottom depending on how the drum is to be placed on its foundation.

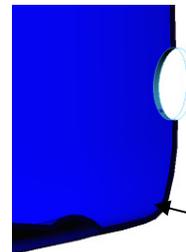
11C Remove and set aside in a safe place the Collection Cross sub assembly so that it is not damaged and is out of the way for the next operation

11D Using a hole saw, drill a 47.75 mm (1.88 inch) diameter hole for the drain. (A side location is shown)

11E Install a bulkhead fitting using the bulkhead fitting procedure.



under the drain to catch the sand that will come out with the water if the sand is to be reused. Washing and reusing the sand saves having to re-sieve the sand to get the right size sand grains for proper filter operation.



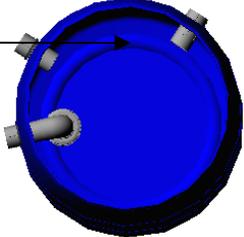
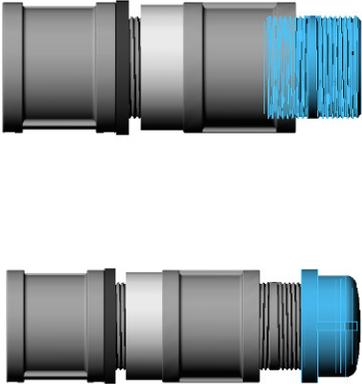
If a side location is chosen, it must be high enough to get above the curved surface at the bottom of the drum.

CAUTION: This operation requires working with a persons head inside the drum. This sets up a confined space situation



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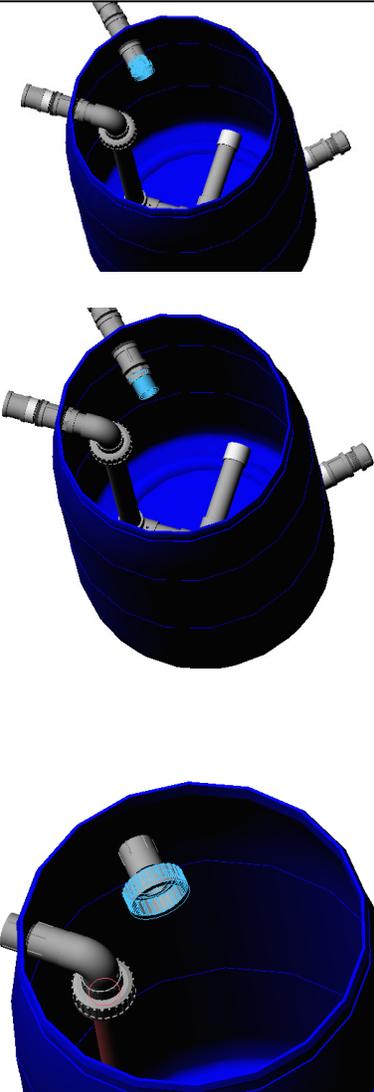
			<p>that requires the person to work quickly so there is no build up of carbon dioxide in the confined space.</p>
<p>12 Place the Sand Retention Screen</p>	<p>12A Wrap the end of the inside of the bulkhead fitting with screen.</p> <p>12B Place a band clamp over the screen and tighten it so the screen is held firmly in place.</p>		<p>CAUTION: This operation requires working with a persons head inside the drum. This sets up a confined space situation that requires the person to work quickly so there is no build up of carbon dioxide in the confined space.</p> <p>The screen prevents the sand in the system from being washed out of the drum when the drain is opened. If this screen is too large sand will be lost anyway. If that happens, stop the drain process and place a cloth on the ground to catch the sand. Failure to recapture the sand will mean it must be re-sieved to get the proper grain size for the filter to operate.</p>
<p>13 Place the outside Drain fitting Plug</p>	<p>13A Thread a length of pipe as needed by the set up of the assembly into the outside of the bulkhead fitting.</p> <p>13B Thread a Female threaded cap onto the male threads of the pipe so that it is tight enough to hold water.</p>		<p>A length of pipe that is long enough to clear any buildings the filter is located in or long enough to have the water drain in an area that will not cause erosion damage to the foundations is needed. The picture shows the shortest length of pipe possible.</p> <p>Placing the cap on the drain fitting tends to tighten the bulkhead fitting. Use caution when removing the fitting as this action tends to loosen the bulkhead fitting. A wrench</p>



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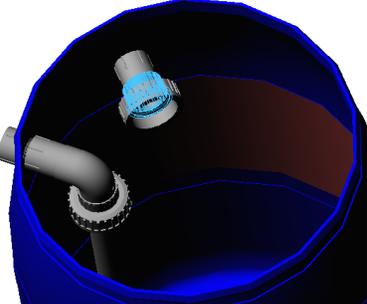
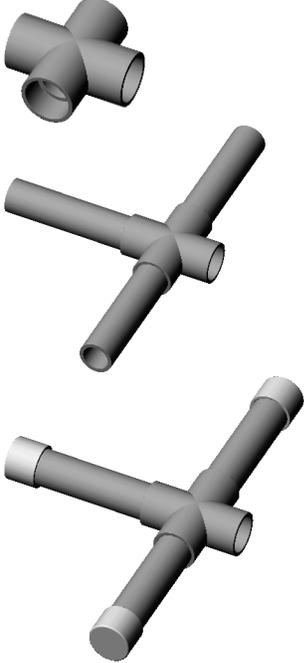
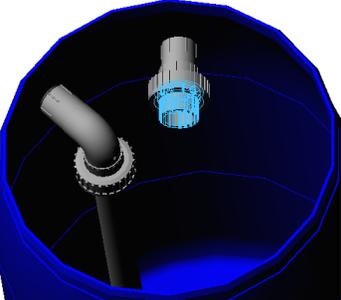
			<p>should be placed on the Transition fitting so that the bulkhead fitting is not loosened when the cap is removed.</p>
<p>14 Place the inside inlet fittings</p>	<p>14A Insert a MPT to slip transition fitting into the inner side of the inlet bulkhead.</p> <p>14A Cut a 50 mm (2 inch) length of 38 mm (1.5 inch) pipe and clean the joint for bonding, Place it into the slip fitting of the female side of the transition fitting. Bond the joint together using primer and PVC glue.</p> <p>14B Place the locking color or the Union over the bulkhead fitting.</p> <p>14C Bond the unthreaded part of the Union fitting to the 2 inch connector using primer and PVC glue.</p>		



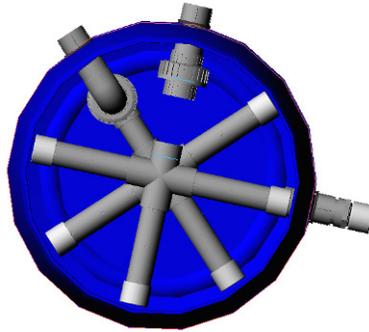
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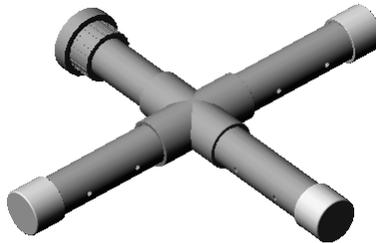
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<p>15 Building the Distribution Cross Arm Subassem- bly</p>	<p>15A Start with a 38 mm cross (1.5 inch)</p> <p>15B Cut three lengths of 38 mm PVC pipe to a length of 216 mm (8.5 inch) and dry assemble them (with out glue at this time) into the partial cross as shown</p> <p>15C Dry assemble caps to the three lengths of pipe.</p>		<p>The collection cross arm length should be as long as possible to provide for the best distribution of flow. This length depends on the diameter of the drum that is used.</p>
<p>16 Measure the length of the Distribution Cross Arm Subassem- bly Connecting Pipe</p>	<p>16A Connect the Threaded part of the Union to the mating part of the Union that is mounted on the inlet line.</p> <p>16B Have an assistant hold</p>		

the Dry assembled Cross Arm piece assembled in step 15 so that it lines up with the Union and is centered in the drum



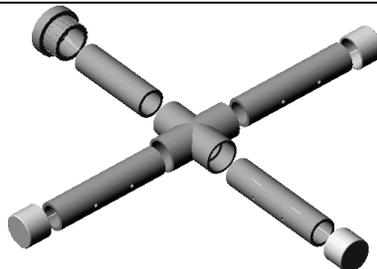
16C Measure the length of pipe needed to connect the slip fitting in the cross in the distribution subassembly with the slip fitting in the unthreaded part of the Union



16D Cut a length of pipe to the measured dimension, remove the unthreaded part of the Union and dry fit the Distribution Cross Arm Subassembly together.

17 Bond the Inlet Cross arm assembly together

17A Disconnect the parts of the Collection Cross sub assembly one by one. At each joint clean the

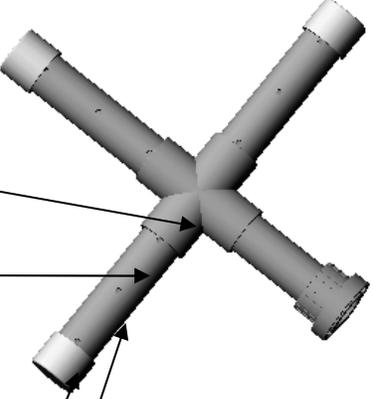




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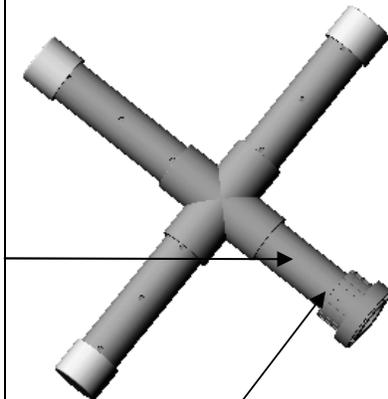
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	<p>joint for bonding, and then bond the joint together using primer and PVC glue. There are 8 joints.</p>		
<p>18 Drill the inlet holes in the inlet cross assembly</p>	<p>18A Drill a 6.35 mm (1/4 inch) VERTICLE hole in the middle of the cross only through the top wall of the cross.</p> <p>18B Drill a 6.35 mm (1/4 inch) VERTICLE hole at the intersection of the cross and the pipe in 4 places only through the top wall of the pipe.</p> <p>18C Drill a 6.35 mm (1/4 inch) VERTICLE hole at the intersection of the End Caps and the pipe in 3 places only through the top wall of the pipe.</p> <p>18D Drill a 6.35 mm (1/4 inch) VERTICLE hole in the pipe</p>		<p>The distribution cross only needs holes on what will be the bottom of the cross. Since the cross can easily be turned over upon assembly, the directions for drilling are given as if the cross is laying on a flat surface.</p>

midway
 between the
 holes at the
 intersection of
 the End Caps
 and the Cross
 in 3 places only
 through the top
 wall of the
 pipe..

18E Drill a 6.35
 mm (1/4 inch)
 VERTICLE hole
 in the pipe
 midway
 between the
 intersection of
 the Union and
 the Cross in 1
 places only
 through the top
 wall of the
 pipe..

18F Drill a 6.35
 mm (1/4 inch)
 VERTICLE hole
 in the pipe at
 intersection of
 the Union and
 the pipe in 1
 places only
 through the top
 wall of the pipe.



Bulkhead Build

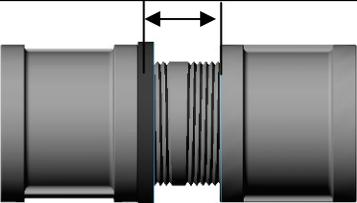
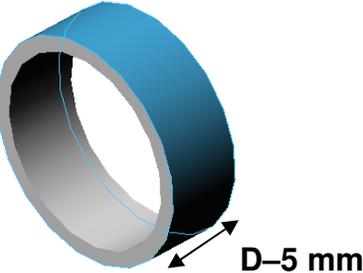
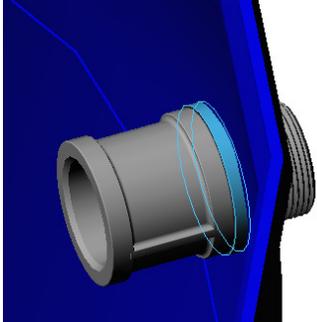
Step Number	Instructions		Rationale
<p>1 Assemble the Inner Side of the Bulkhead Fitting</p>	<p>1A Start with a 38 mm (1 ½ inch) galvanized coupling and a 38 mm (1 ½ inch) short pipe nipple. The threads of the nipple should be nearly touching each other.</p> <p>1B Thread the pipe nipple into the galvanized coupling so that at least 3 full threads are engaged but no more than 5.</p> <p>1C Install a rubber gasket over the nipple and snug against the coupling.</p>		<p>Three full threads are required to assure the threads will not be stripped when the bulkhead is tightened. Engaging more than 5 threads will not leave enough room for the rest of the assembly to be properly fitted together.</p> <p>Any gasket material can be used that is suitable to seal against water. The assembly is sized to accommodate variable thickness of gaskets (see next step).</p>
<p>2 Measure for the length of the spacer and cut the spacer.</p>	<p>2A Thread a second galvanized coupling onto the inner side so that at least 3 full threads</p>		

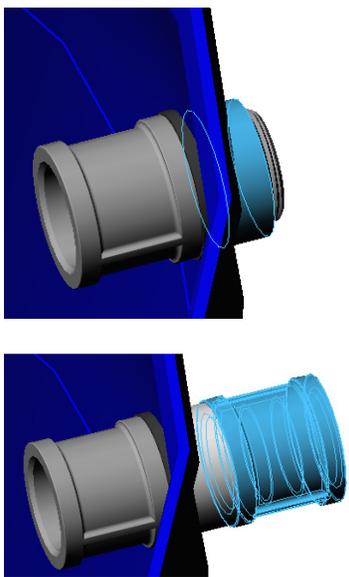


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	<p>are engaged but no more than 5.</p> <p>2B Measure the distance “D”.</p> <p>2C Subtract 5 mm from the measured distance “D” and record the value as the length of the spacer needed.</p> <p>2D From a length of 51 mm (2 inch) diameter pipe cut a length of spacer equal to the length found in step 2C.</p>	 <p>Spacer Length _____ mm</p> 	
<p>3 Assemble the bulkhead fitting</p>	<p>3A After a 48 mm (1.88 inch) hole has been drilled in a plastic drum per the assembly instructions of the drum under assembly, remove the outer coupling and place the inner coupling and nipple into the inside of the drum through the drilled hole so that the</p>		

	<p>gasket is firmly against the inside of the drum.</p> <p>3B Place the spacer on the outside part of the nipple.</p> <p>3C Thread the outer coupling onto the pipe nipple.</p>		
<p>4 Tighten the bulkhead fitting into place</p>	<p>4A Place a pipe wrench onto the inner coupling in the direction so that it can hold the coupling still during the next set of operations.</p> <p>4B Using two pipe or strap wrenches, tighten the outer coupling without twisting the gasket against the drum surface.</p>		

6.0 Assessment and Monitoring Plan

6.1 Water Quality Monitoring

The goal of the Water Quality Monitoring Plan is to ensure that the BYOW system is working properly and providing safe drinking water. The two main water quality parameters to be monitored are turbidity and bacterial counts in both the source water and the product water. In addition, intermediate samples collected downstream of the sand filter and upstream of the UV light will be collected intermittently. The key goal of the BYOW is the removal of pathogenic microorganisms from the source water by filtration and ultraviolet disinfection. Although some turbidity is expected in the source water, the product water must be clear and without cloudiness. The UV disinfection step requires low turbidity, as suspended particles, such as clay, can shield bacteria from the UV light.

Turbidity is monitored with a turbidimeter and bacterial monitoring is conducted with plates. 3M Petrifilm E. coli count plates are used for the enumeration of Escherichia coli and coliforms. E. coli are an intestinal organisms that indicates the water was contaminated by fecal matter. Coliform are easy to culture and their presence is used to indicate that other pathogenic organisms of fecal origin may be present. Coliform may also come from non intestinal sources such as soil and vegetation.

Unlike the general coliform group, E. coli are almost exclusively of fecal origin and their presence is thus an effective confirmation of fecal contamination. Typically, E. coli are about 10% of the coliforms in human feces.

The method is based on sample collection, inoculation of the plate with the liquid sample, incubation, and counting of colonies. A summary of each step is provided here. See the Hach Turbidity meter and 3M Petrifilm brochures for more details.

Sample Collection

Turbidity measurements require 15 mL of liquid sample and each bacterial plate measurement requires 1 mL of water, which is applied directly to the plate. The sample to be measured should be collected in a clean container that has been flushed three times with product water (effluent from the BYOW system).

Frequency of Sample Collection

The BYOW system should be visually inspected weekly. Samples should be collected at least monthly for turbidity and bacterial counts. More frequent sampling should be conducted when there is an observable change in the product water, such as visible cloudiness, color, or odors.



Monitoring of Turbidity

The Hach 2100P Portable Turbidimeter is used to measure turbidity quantitatively from 0 to 1,000 NTU (nephelometric turbidity units). In addition to the Hach turbidimeter, which gives a digital readout of the turbidity, turbidity can be assessed qualitatively by visual inspection of the water sample in a clear bottle. However, care should be taken, as a visually clear sample may still contain bacteria. Turbidity monitoring is best suited for monitoring the effectiveness of the sand filter, which removes suspended matter before UV disinfection.

1. Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by the top. Cap the cell.
2. Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints.
3. Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.
4. Press: I/O. The instrument will turn on. Place the instrument on a flat, sturdy surface. Do not hold the instrument while making measurements.
5. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment. Close the lid.
6. Select manual or automatic range selection by pressing the RANGE key. The display will show AUTO RNG when the instrument is in automatic range selection.
7. Select signal averaging mode by pressing the SIGNAL AVERAGE key. The display will show
SIG AVG when the instrument is using signal averaging. Use signal average mode if the sample causes a noisy signal (display changes constantly).
8. Press: READ The display will show - - - - NTU, then the turbidity in NTU. Record the turbidity after the lamp symbol turns off.

Note: The instrument defaults to the last operating mode selected. If automatic range mode and signal averaging were used on the previous measurements, these options will automatically be selected for subsequent samples.

Measurement Notes

Always cap the sample cell to prevent spillage of sample into the instrument.

When taking a reading, place the instrument on a level, stationary surface. It should not be held in the hand during measurement.

Always close the sample compartment lid during measurement and storage.

Always use clean sample cells in good condition. Dirty, scratched, or damaged cells can cause inaccurate readings.

Do not leave a sample cell in the cell compartment for extended periods of time. This may compress the spring in the cell holder.

Remove sample cell and batteries from instrument if the instrument is stored for extended time period (more than a month).

Avoid operating in direct sunlight.

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Make certain cold samples do not “fog” the sample cell.
 Avoid settling of sample prior to measurement.
 Keep sample compartment lid closed to prevent dust and dirt from entering.

Measurement Techniques

Proper measurement techniques are important in minimizing the effects of instrument variation, stray light and air bubbles.
 Regardless of the instrument used, measurements are more accurate, precise and repeatable if the analyst pays close attention to proper measurement techniques.
 Measure samples immediately to prevent temperature changes and settling. Avoid sample dilution when possible. Particles suspended in the original sample may dissolve or otherwise change characteristics when the sample temperature changes or when the sample is diluted, resulting in a non-representative sample measurement.

Cleaning Sample Cells

Cells must be extremely clean and free from significant scratches. The glass used to make cells is easily scratched – manufacturing cells free of minor scratches and other imperfections is difficult. However, minor imperfections are effectively masked by applying silicone oil. Clean the inside and outside of the cells by washing with BYOW product water. Follow with multiple rinses of distilled or deionized water. Allow cells to air dry. Handle cells only by the top to minimize dirt, scratches and fingerprints in the light path.

Monitoring of Bacteria, Description:

The 3M Petrifim E. coli Count Plate is a sample-ready medium system for enumerating Escherichia coli and other coliforms. Petrifilm E. coli Count plates contain violet red bile nutrients, a cold water soluble gelling agent, a glucuronidase indicator to identify E. coli, and a tetrazolium indicator to enhance the visualization of other gram coliform negative (non-E. coli) bacteria.

Coliforms ferment the lactose in the medium to produce gas. This gas is trapped around the coliform colony and allows the differentiation of coliform bacteria from other gram negative bacteria. In addition, glucuronidate, produced by most E. coli will react with the glucuronidase indicator in the medium to produce a blue precipitate around the colony allowing visual identification of E.coli.

Storage and disposal:

Store unopened Petrifilm plate foil pouches at or below 80C (460F). After opening, return unused plates to foil pouches. Seal foil pouch by folding and taping the open end. Store resealed pouches at room temperature (<25C or <77F) with <50% RH. Exposure of Petrifilm plates to higher temperatures and/or humidities can affect the performance of the plates. Do

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not refrigerate opened packages. Use Petrifilm plates within one month after opening. Do not use plates that show orange or brown discoloration.

After use, Petrifilm E. coli Count plates will contain viable bacteria. Follow current Industry standards for disposal.

Directions for use:

1. Place the Petrifilm E. coli Count plate on a flat surface (see figure A).
2. Lift top film and dispense 1 ml of sample onto the center of the bottom film (see figure B).
3. Slowly roll the top film down onto the sample to prevent the entrapment of air bubbles (see figure C).
4. Distribute sample evenly within the circular well using a gentle downward pressure on the center of the plastic spreader (flat side down) (see figure D). Do not slide spreader across the film. Remove spreader and leave plate undisturbed for one minute to permit solidification of the gel.
5. Incubate plates in a horizontal position with the clear side up in stacks not exceeding 20 plates. Follow current industry standards for incubation temperature. Incubate plates 24 ± 2 hr. and examine for coliform and E. coli growth. Some E. coli colonies require additional time to form the blue precipitate. Re-incubate plates an additional 24 ± 2 hr. to detect any additional E. coli growth.
- 6a. Petrifilm E. coli Count plates can be counted on a standard colony counter. The interpretation of E. coli colonies on Petrifilm E. coli Count plates varies by method. When considering which interpretation to follow please keep in mind that approximately 95% of E. coli produce gas.

AOAC Method (991.14)

Petrifilm plates incubated at $35 \pm 1^\circ\text{C}$

Blue colonies associated with entrapped gas (see figure F) are confirmed E. coli. Blue colonies without gas are not counted as E. coli.

Other coliform colonies will be red and associated with gas bubbles. Colonies not associated with gas (with a distance greater than one colony diameter from gas bubble) are not counted as coliforms. The total coliform count consists of both the red and blue colonies associated with gas at 24 hours.

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Data Monitoring Form for Turbidity

Samples collected by _____ on _____

Location: _____

Sample Location	Date of Collection	Turbidity, NTU	Visual Observations

Data Monitoring Form for E. coli and coliform using 3M Petrifilm Plates

Samples collected by _____ on _____

Sample Collections Location and Project: _____

Incubator conditions, Storage Temperature = _____

Time plates placed in Incubator = _____

Time plates removed from Incubator = _____

Time colonies were counted = _____

Sample Location	Date of Collection	Sample Dilution = 1 for undiluted	# of E Coli colonies (blue) per sample volume, mL	# of coliform colonies (red) per sample volume, mL

3M Petrifilm E. Coli plates

Notes:

One Blue colony (dot) associated with gas bubble is counted as one E. Coli colony.

One Red colony (dot) associated with gas bubble is counted as one coliform colony.

Usage Monitoring

An important assessment of the effectiveness of the BYOW system is the number of users of the system. The ideal water treatment system is only useful if it is used by the target population. The goal of usage monitoring is to quantify the number of water batches processed and estimate the number of end users of the BYOW treated water. In order to count the number of users, an observer will monitor uses with the following form. The monitoring program frequency should be sufficient to capture daily, weekly, and seasonal patterns of use and non-use. If possible, the observer should acquire additional information from the water carrier, such as the end-uses of the water and the number of people served by the individual water carrier.

Observed number of users of BYOW system

Date =	
Time Period that observations were made =	
Observer Name =	
System monitored (e.g. BYOW at Orphanage) =	

Time of Use	User Sex & Estimated Age	Volume of Water	Type of Container	Other



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Time of Use	User Sex & Estimated Age	Volume of Water	Type of Container	Other

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In-Depth Water Carrier Survey

Age:

Sex:

How often do you carry water daily, weekly?

Where is the water source? How far do you walk?

What volume of water do you carry?

How many people use the water that you carry?

What is the water used for?

What container do you use? Are you happy with it? Can you think of a better container?

Do you think the water that you carry is safe to drink?

Do you volunteer to carry the water? Who asked you to carry water? Do you enjoy carrying water?

Have you heard about the EWB BWOW system? What do you know about it? Do you plan to use it?

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Public Health Monitoring

Goals

Quantify community health conditions for the two-year period prior to installation of EWB BYOW system.

Quantify community health conditions for period following installation of EWB BYOW system.

Tasks to accomplish objectives

1. Interview orphanage representatives and hospital representatives to obtain available data on incidence of water-related illnesses, such as diarrhea.
2. Conduct following surveys with orphans and users of BYOW system.

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EWB-USA provided Public Health Assessment Forms

Instructions:

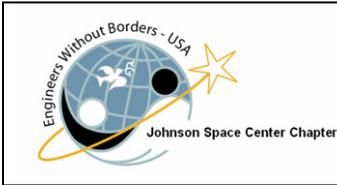
The interviewer will need to determine the geopolitical and population boundaries of the “community” the EWB project will serve and then repeatedly refer to those boundaries when conducting the interviews.

You should be completing the entire attached survey with 4-8 individuals in the community (see required vs. specific project questions). There may be different ideas from different people about what is an illness and its cause so information from a cross section of the community will be more valuable.

Your sources of information should include one or two individuals from each of the following groups of people. Both genders should be represented and at least 1/3 to 1/2 of the individuals should live within the community your project will serve. If there is more than one ethnic group that will benefit from your project try to include people from each group.

- 1) Village leaders (ask around to find out who are considered leaders, both formal and informal)
Some examples include: the village headman or elder, president of the women’s club, local government official.
- 2) Health care providers such as: clinic doctor or nurse, health aide, local midwife, traditional healer or Health Ministry official.
- 3) Educators such as: health educator, school teacher, headmaster or professor.
- 4) Employee of a non-governmental organization working in the area, for example: a Peace Corps volunteer, missionary or employee of a national non-governmental agency.
- 5) Your own observations

Ask each individual all of the required questions (indicated with **, italics and in blue) and as many of the other questions as you are able to get information about based on time and willingness to respond. Some of the ‘extra’ questions will be more appropriate for your project than others. The Health Metrics representative will assist you, if needed, in deciding which of the extra questions are important.



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Final Report:

As part of your report turned in at the end of your project please state at least two or three ways that you plan to show how your EWB project will improve some element of the community's quality of health or standard of living, for example, fewer cases of diarrheal illnesses in children under five, fewer deaths of women in childbirth, increased immunization rates, increased percentage of households with latrines, etc. Based on the information collected from your surveys: 1) How will you measure the impact of your project? 2) Who will measure it and how will you get the data?

- Section 1: Regional Demographics
- Section 2: Community Illness / Injury Information
- Section 3: Morbidity / Mortality Information
- Section 4: Daily living information
Water, Food, Sanitation
- Section 6: Education / Health Education
- Section 7: Transportation / Communication
- Section 8: Goals of EWB Project

Baseline / Follow-up

EWB Community and Health Assessment Survey

Project _____ *Chapter(s)*

Date of survey _____ *Location (home, health clinic, community house....)*

Source of Information (name and role in community) _____

Section One: Regional Demographics

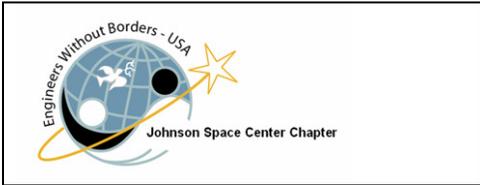
****How many people will benefit from this project?** _____

For the entire community:

****Number of families:** _____

****Number of adult men (16 years or older):** _____

****Number of adult women (16 years or older):** _____



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****Number of children ages < 1 year _____ 1-4 years _____ 5-15 years _____**

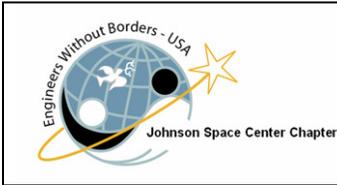
****Number of elders greater than 50 years _____**

****What ethnic groups or tribes live in the area that will be served by the project and the approximate size of each group**

What is the average age that women start to have children

Average number of children per woman of childbearing age. _____

Number of disabled persons in the community (mental and physical) _____



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Section 2: Community Illness / Injury Information

***What are the 5 most important illnesses/injuries affecting people in the community?*

1. **Illness or injury**

Estimate the number/percentage of children _____ younger adults _____ older adults _____ w/ this problem every year.

Is this illness/injury gender specific? If so, does it affect more men or women? _____

What do people think is the cause of this illnesses/injury or condition in the community? _____

How is it treated? By whom? Where? _____

2. **Illness or injury**

Estimate the number/percentage of children _____ younger adults _____ older adults _____ w/ this problem every year.

Is this illness/injury gender specific? If so, does it affect more men or women? _____

What do people think is the cause of this illnesses/injury or condition in the community? _____

How is it treated? By whom? Where? _____

3. **Illness or injury**

Estimate the number/percentage of children _____ younger adults _____ older adults _____ w/ this problem every year.

Is this illness/injury gender specific? If so, does it affect more men or women? _____

What do people think is the cause of this illnesses/injury or condition in the community? _____

How is it treated? By whom? Where? _____

4. **Illness or injury**

Estimate the number/percentage of children _____ younger adults _____ older adults _____ w/ this problem every year.

Is this illness/injury gender specific? If so, does it affect more men or women? _____



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What do people think is the cause of this illnesses/injury or condition in the community? _____

How is it treated? By whom? Where? _____

**5. Illness or
injury**

*Estimate the number/percentage of children _____ younger adults _____ older
adults _____ w/ this problem every year.*

Is this illness/injury gender specific? If so, does it affect more men or women? _____

What do people think is the cause of this illnesses/injury or condition in the community? _____

How is it treated? By whom? Where? _____

***Is there a difference between the overall health of women and the health of men?*

***If yes, what? _____*

Is malaria considered a problem in the community?

What is done to prevent malaria?

What is done to treat malaria?

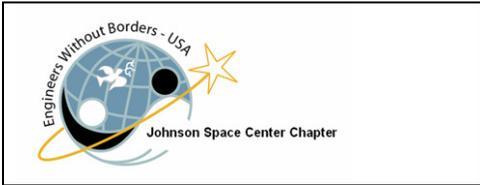
Is HIV/AIDS considered a problem in the community?

Is testing for HIV/AIDS available? _____ If so, where?

Is tuberculosis (TB) considered a problem in the community?

Where do most of those with TB go for treatment?

If so, where is treatment or medication available?



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Section 3: Morbidity / Mortality Information

****What is the average life span of women? _____ men?**

****Total number of births in the community each year _____**

****Total number of deaths in the community each year _____**

****Number of children less than 1 year old that die each year _____**

****Most common causes of death :** #1 _____
#2 _____
#3 _____
#4 _____
#5 _____

****Are there certain diseases that always occur at specific times of the year? Explain. _____**

Number of children from 1 to 5 years old that die each year

Number of women who die during childbirth each year

Section 4: Daily living information

Water

****Where do people get water (streams, springs, household taps, community taps, rainwater, wells)?**

For drinking:

For cooking:

For bathing:

For hand-washing:

For animals:

For irrigation:

****On average, how far do people have to travel to get to their drinking water source? _____**



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***Is there enough water during all times of the year? If not, during which season(s) is there not enough?*

If wells are used, how many are there?

Where are the water sources located?

What are the methods of water purification used in the area?

Food

***Describe a typical meal.*

***Is there enough food for everyone during all times of the year?* _____

***Is malnutrition a problem? _____ What are the problems? _____*

Where and how do people get food? What ways are used to acquire food (e.g. grazing, hunting, farming, brought into local market from outside the community, etc.)? _____

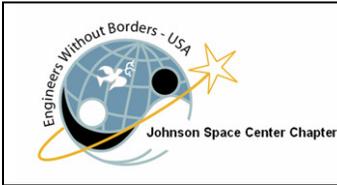
How many meals a day do people eat?

How does a child's diet differ from an adult?

How does a woman's diet differ from a man's?

Does this change when the woman is pregnant?

What, if any foods are considered taboo? _____



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What percentage of women breastfeed their children. _____

Sanitation

***What do people use for bathroom facilities and what is the approximate percentage of each?*

Flush toilet _____ **Indoors** _____ **Outdoors** _____
Pit latrines _____
Neighboring fields _____
Other, describe _____

***How do people dispose of their garbage?*

What percentage of homes have bathroom facilities (either indoors or outdoors)?

Are there community bathroom facilities? How many and where are they?

Are bathroom facilities of some sort available to all community members? _____

Are there community garbage dumps? If so, where are they located?

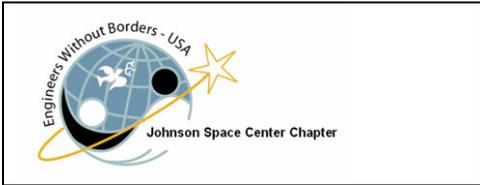
Section 5: Community Health Resources

***What is the nearest health facility? Is this an in-patient facility (people spend the night like in a U.S. hospital) or outpatient only?*

***Who staffs this facility? (physician, nurse, health aide, traditional healer)* _____

***Does the health facility have constant, reliable electricity (24/7)?* _____

***How do most people get to this facility?* _____



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****What types of traditional health care providers are in the community?** _____
_____ How many of each type are there?

****What percentage of children in the community is immunized?** _____

****What are the barriers to immunization? (cost, transportation, availability, lack of electricity, cultural taboos, other...)** _____

****What public health programs are functioning in the community?** _____

How far is it from the community? _____

Is transportation a barrier to obtaining medical treatment? _____

Is cost a barrier to obtaining medical treatment?

Where do these traditional health care providers receive their training and what sort of training do they receive?

Where do the children receive immunizations?

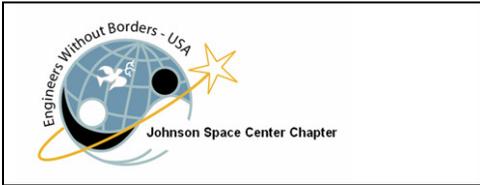
What immunizations are available for children (Measles, Mumps, Rubella, tetanus, polio, pneumovax, influenza, Hepatitis A, Hepatitis B, other _____)

Who provides the vaccines/immunizations?

Do parents pay for the vaccines?

Where do people get their medications?

How do they pay for their medications?



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Section 6: Education / Health Education

***Is there a school(s) in the community? (how man and what types, and how many students in each)*

Primary
 # of schools _____ # of students in each _____

Secondary
 # of schools _____ # of students in each _____

University / Technical college / Vocational
 # of schools _____ # of students in each _____

Religious
 # of schools _____ # of students in each _____

***What is the literacy rate in the region?*

Percentage of those who can read _____, write _____, sign their name only _____

***To whom does the community turn for health information / education? (family, village nurse, traditional healers, teachers, radio, TV)*

Is there a health educator in the community?

If they are not the same person, do the health educators have a good relationship with the health care providers in the community?

Section 7: Transportation / Communication

***Does public transportation go into the community?* _____

What (bus, train, trucks....)? _____

***How many households have, or have regular, unlimited access to:*

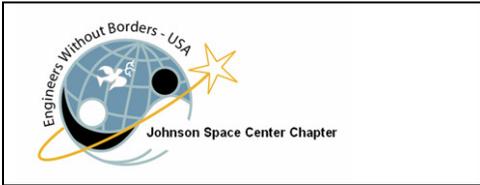
radio _____

television _____

a telephone (cellular or landline) _____

access to a newspaper _____

a vehicle _____



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Section 8: Goals of EWB Project

**How do you think this project will benefit the community? _____

Based on above data:

**How will you measure the impact of your project? _____

**Who will measure it and how will you get the data? _____

Community Assessment Survey – EXAMPLE

Family Name:
Address:
Number of children in household:
Number of adults in household:

1. Have you heard why we're here?
2. What do you think of the project?
3. What are your main concerns regarding water?
4. How do you think these problems should be solved?
5. What is your primary source of water?
6. What are the most common source of illnesses?
7. How much water do you use for drinking, washing, cooking, and other?

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8. Who collects the water and how? How much does it cost?
9. Where are the latrines, especially in relation to the water sources?
10. Where does waste end up?
11. What is the main source of income for your family?
12. How much would you be willing to spend per month on clean water?
13. Are you able to pay for your medical expenses?
14. Do the children attend school? How often and up to what level?