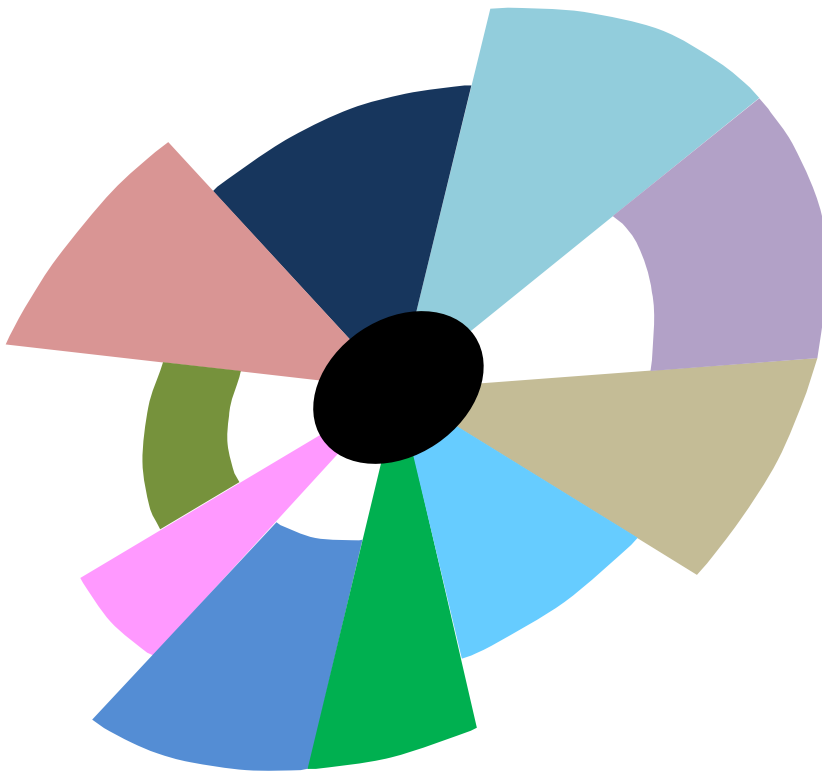

WATER SAFETY PLAN

FOR
SONO ARSENIC REMOVAL
TECHNOLOGY



BETV-SAM



DPHE



ITN

JUNE, 2007

Introduction

A draft of this first edition of a water safety plan (WSP) for the SONO Arsenic Removal Technology (ART) was prepared in 2006 and presented on April 10, 2007 at the “Review Workshop on the Implementation and Development of Water Safety Plans” workshop that was held in Dhaka and organised by WHO and DPHE in cooperation with BETV-SAM and ITN-BUET. During the workshop, representatives from government, NGO and development partner organisations participated in review sessions and provided valuable comments and suggestions regarding the draft WSP. Version 1.0 of this WSP was then finalised in June 2007 and provided for use in Bangladesh.

If a government or non-government organisation that applies this WSP for the SONO ART feels that minor changes are required based on their own water supply programme, the concerned organisation should maintain a record of all the changes on the following sheet.

Document Change Record Sheet

Location	Changes made	Remarks

Table to be completed, as necessary, to keep track of any changes that are made to the WSP in the future.

Pro-formas

Table 1. The WSP Team

The first step of implementing the WSP is to form a team of people from the implementing organisation/s working on water safety plans for ARTs. It is preferred that the team will include people from different disciplines and those having commitment and technical ability to develop and implement the WSP.

Name	Affiliation	Title	Role in WSP team	Contact Information			
				Address	T	F	E

The WSP documents are dynamic documents. As new information and experience becomes available about the SONO ART or the performance of the WSP, the document can be improved and modified to reflect these changes. Therefore, the implementing organisations should assign a person who will be responsible for updating the WSP and disseminating it to WSP team members through a set process of the organisation.

Document development history:

Version	Date
1 st version	June 2007 by BETV-SAM

Document Approved by: _____ Name: _____

Date: _____

Table 2. Water supply process description.

Step	Description
Water source	Abstraction from groundwater via a hand pump fitted tubewell. Tubewell water is collected in clay or metal pitchers and transferred into the top bucket of the SONO ART.
Water treatment process	Water flows through 2 buckets that are placed in series. The top bucket contains brick chips, coarse sands and iron casting, and the bottom bucket contains brick chips, coarse and fine sands, and charcoal.
Distribution of water	Treated water is collected from a tap on the lower bucket, as a point source.
Collection and storage of treated water by individual household members	Water is collected from the SONO ART, generally using clay or metal pitchers and either directly consumed from the pitcher or transported to the kitchen area in the individual household for storage and use (may include transfer between containers).
Operation and Maintenance (O&M) controls required	<p>The SONO ART includes 2 buckets (with lids) that are placed one on top of the other on an iron stand. Each bucket is fitted near the bottom with a valve to control water flow. The top bucket is red and is packed with brick chips, coarse sands, and iron casting. The bottom bucket is green and is packed with brick chips, coarse and fine sands, and charcoal. The media in each bucket are separated by a sheet of polyester mesh and the two buckets are connected by flexible tubing that extends from the valve on the bottom of the top bucket through the lid of the bottom bucket.</p> <p>To operate the SONO ART, the lid is removed from the top bucket, and approximately 22-25 litres of water is collected from the tubewell in a suitable clean container and poured into the top bucket of the ART. Once the transfer of water is complete, the lid is replaced on the top bucket. Water is gravity fed through the ART and treated water is collected in a clean container from the valve on the bottom of the bucket. The first 3 or 4 batches of treated water are required to flush the media and should be discarded.</p> <p>Maintenance for the SONO ART includes flushing each bucket with boiling water on a weekly basis to help keep the ART free from pathogens. This can be done by flushing each bucket with 2-3 litres of boiling water, or pouring 5-7 litres of boiling water into the top bucket and letting it drain down into the bottom bucket. The upper sand layer in the top bucket should be replaced (either partially or completely) every 4-6 months, or when flow is noticeably slower, to prevent clogging of the media and to restore normal flow. The valves should also be picked gently with a sewing needle on a regular basis to minimise the effect of clogging with sand and iron flocs.</p> <p>The media in both buckets should be replaced when required by the deployment conditions that are attached to the Verification Certificate.</p> <p>Further details are provided in the SONO Operations and Maintenance manual (attached).</p>
Treated water quality requirements	Water quality should comply with the Bangladesh standard for arsenic in drinking water (GoB, 1997) and the WHO drinking water guidelines for other water quality parameters.

Table 3. Intended uses of water and nature of consumers, information capture form.

Intended Use	Intended Consumer
<ul style="list-style-type: none"> • Water is collected from the ART and is used for drinking and cooking purposes. • Individual members of the household are responsible for the operation and maintenance of the SONO ARTs. • Water should meet safety and quality (aesthetic) standards i.e. Bangladeshi standard for arsenic in drinking water (GoB, 1997), and the WHO drinking water quality guidelines for other parameters: • Safety requirements: <ul style="list-style-type: none"> • Arsenic • <i>E. coli</i> and sanitary inspection score • Nitrate • Manganese • Turbidity • etc. • Aesthetic requirements: <ul style="list-style-type: none"> • Iron • Chlorine (residual) • Odour • Taste • Colour • Turbidity • etc. 	<ul style="list-style-type: none"> • The users are people residing in arsenic-affected areas and include the healthy, young, old, pregnant, disabled and immune-compromised. • The users have different levels of education and income, and will require appropriate training on the operation and maintenance of their SONO ART. • The users may collect treated water from the ART in pitchers that are not clean and/or store the water in unsanitary conditions, thereby increasing the risk of microbial contamination. Controlling these risks requires hygiene education about the safe water chain by hygiene education staff working at the Union and Upazila level. • SONO ARTs should be monitored and inspected (as outlined in “Table 7: Operational Monitoring Schedule”) according to a regular schedule.

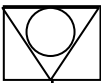







Table 4. Technology description.

To be completed by each organisation applying WSP for SONO ART

Issue	Information	Attached documents
Verification certificate information	The SONO ART received provisional verification for deployment in Bangladesh. With new media, the ART can be operated for 6 months to produce treated water with arsenic concentrations below 50 µg/L at the rate of 45 litres per day to meet the daily cooking and drinking water needs of a rural family of 5 persons where influent water contains arsenic ≤ 750 µg/L, iron ≤ 10 mg/L, phosphate ≤ 4 mg/L and pH ≤ 7.5.	ETV-AM Provisional Technology Verification Statement
Standard design	The source tubewell is equipped with a handpump. The SONO ART includes 2 buckets with lids that are placed on an iron stand. The top bucket (red in colour) is packed with brick chips, coarse sands, and iron casting. The bottom bucket is green and is packed with brick chips, coarse and fine sands, and charcoal. The beds of media in each bucket are separated by a sheet of polyester mesh and the two buckets are connected by flexible tubing that extends from the valve on the bottom of the top bucket through the lid of the bottom bucket. Treated water is collected from a tap on the lower bucket.	SONO Arsenic Removal Technology Operation and Maintenance Manual
System capacity specifications and people served by ART	The SONO ART can be used in Bangladesh to produce arsenic-safe water at a rate of 45 litres per day for 6 months. This is enough water to serve the cooking and drinking purpose of a rural family of five.	ETV-AM Provisional Technology Verification Statement
Materials specification	The media from the SONO ART can be replaced with sand, brick chips, charcoal and composite iron material produced in Bangladesh. The buckets should be food grade quality.	
Usual setting	The SONO ART is a household unit that should be installed in a secure place, near the tubewell.	
Source protection measures required	All tubewell protection measures that are outlined in the WSP for tubewells should be followed.	Latest edition of the Water Safety Plan for Tubewells
Requirements to characterise well prior to installation of ART	Prior to installation of the ART, well characterisation samples are analysed to ensure that the tubewell complies with the deployment conditions outlined in the Verification Statement and the WHO drinking water quality guidelines for concentrations of manganese, boron, etc.	ETV-AM Provisional Technology Verification Statement

Issue	Information	Attached documents
<p>Operation and maintenance requirements</p>	<p>The SONO ART is operated by household members. Raw water is collected from the tubewell in a clean container and poured into the top bucket of the SONO ART. Water is gravity fed through the top bucket and into the lower bucket. Treated water is collected from the tap of the lower bucket.</p> <p>Required maintenance includes flushing the media with boiling water weekly to keep the ART free from pathogens. This can be done by flushing each bucket with 2-3 litres of boiling water, or pouring 5-7 litres of boiling water into the top bucket and letting it drain down into the bottom bucket. The upper sand layer in the top bucket should be replaced (either partly or completely) every 4-6 months, or more frequently if flow is noticeably slower, to remove iron flocs and restore normal flow. The valves should also be picked gently with a sewing needle on a regular basis to minimise the effect of clogging with sand and iron flocs.</p> <p>The media in both buckets should be replaced according to the verification certificate schedule.</p>	<p>SONO Arsenic Removal Technology Operation and Maintenance Manual</p>
<p>Training requirements</p>	<p>The supplier of the ART is required to provide at least one individual in the household with training on the operation and maintenance of the SONO ART and provide or arrange for hygiene education.</p>	

Table 5. Process flow diagram.

Code	Step	Description	Responsibility
ART1		Source (tubewell)	Caretaker/ household
ART2		Collection and Transfer (from tubewell into arsenic removal technology)	Household
ART3		Transfer (water flows from top bucket into bottom bucket)	Household
ART4		Treatment (arsenic removal technology)	Household
ART5		Collection (in pitchers, from technology outlet)	Household
ART6		Transport (from ART into household)	Household
ART7		Storage (on site, at the point of use)	Household
ART8		Use (drinking and cooking)	Household

Symbols:






Key:		Storage		Operation
		Inspection		Transport
		Delay		

Table 6. Hazard analysis.

Process Step (code from pro- forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk ¹	Additional Control Measures Required to Help Reduce Risk
ART1 Source (tubewell)	Contaminated water is supplied to the ART due to improper installation, operation or maintenance of the tubewell	Nitrate, nitrite, microbial (B,V,P) ²	Conduct tubewell inspection and ensure that the tubewell complies with the requirements of the Water Safety Plan for Tubewells document	S	Design programmes with involvement from the communities in water supply development and promote the importance of the tubewell water safety plans
	Concentrations of harmful inorganic contaminants in the tubewell water, other than arsenic and iron , exceed the WHO drinking water quality guidelines	Chemical and physical contaminants	Prior to selection and installation of the ART, well characterisation samples are collected and analysed to ensure that, except for arsenic and iron , the tubewell water is safe. If concentrations of manganese and/or boron exceed the WHO guidelines, the tubewell should not be used and another tubewell should be selected as the drinking water source.	U	Promote the importance of sampling wells, reviewing ART deployment conditions and selecting appropriate ARTs
	Water quality of tubewell is not sufficiently assessed and compared to deployment conditions attached with the ART Verification Certificate to determine the appropriateness of the SONO ART	Arsenic contamination due to inappropriate ART selected for tubewell	Ensure that the water quality data from the tubewell is reviewed and concentrations of key water quality parameters comply with the deployment conditions: <ul style="list-style-type: none"> • arsenic ≤ 750 µg/L • iron ≤ 10 mg/L • phosphate ≤ 4 mg/L • ph ≤ 7.5 	U	Promote the importance of sampling wells, reviewing ART deployment conditions and selecting appropriate ARTs
ART2 Collection and Transfer (from tubewell into ART)	Collect water in unsanitary container	Microbial (B,V,P)	Clean and/or disinfect water container regularly with ash (Bangladesh rural context), detergent or soap, and rinse well with clean water.	S	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation
	The collector does not practice good sanitary practices (such as dipping his/her fingers into collected water, etc.)	Microbial (B,V,P)	Ensure that tubewell water enters the collection container directly and does not come into contact with any possible sources of contamination such as hands, utensils, etc. Ensure that the raw water is poured directly into the ART and the lid is replaced on the top bucket immediately after the transfer. The collection container should be covered during transport from the tubewell to the ART. Also, sanitize the ART spout regularly to keep it clean and free from contamination.	S	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation

¹ Risk type: S = significant, U = uncertain, I = insignificant

² Microbial contamination: B = bacteria, V = viruses, P = protozoa

Water Safety Plan for SONO Arsenic Removal Technology: Version-1

Process Step (code from pro- forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk ³	Additional Control Measures Required to Help Reduce Risk
ART3 Transfer (water flows from top bucket to lower bucket)	Microbial contamination due to leakage in pipe and tap between the buckets	Microbial (B,V,P)	Ensure that the household members inspect the tubing and taps regularly any leaks	S	Provide household with O&M manual and appropriate training including hygiene education Extra spare parts should be made available by the proponent
ART4 Treatment (with arsenic removal technology)	The ART does not perform satisfactorily, and produces treated water with concentrations of As > 50 µg/L or other contaminants (iron, turbidity, etc.) that exceed the WHO drinking water quality guidelines due to fouling of the ART media (specifically with iron) and improper operation and maintenance	Arsenic and chemical contamination due to fouled media	Ensure that the ART is operated (including discarding the first three or four batches upon startup to ensure that the media is flushed) and maintained according to the requirements of the ART-specific operation and maintenance (O&M) manual, including replacing the upper sand layer in the top bucket to remove iron flocs and restore normal flow.	S	When ART is installed, household members are provided with an O&M manual and appropriate training from the ART provider to ensure that the ART is operated according to the SONO requirements and undergoes regular maintenance (flushing the media with boiling water, replacing the top layer of sand in the top bucket, and picking the valves to keep them clear from sand and iron flocs). A follow-up program to monitor the effectiveness of the training is recommended. Also ensure that the operators of the ARTs are provided with hygiene and sanitation education, especially with respect to ART operation and maintenance.
	Microbial contamination due to inadequate ART maintenance, poor hygienic practices when operating and maintaining the ART	Microbial (B,V,P)	Ensure that the household members flush the ART weekly with boiling water to help keep the unit free from pathogens, use a clean sewing needle when picking the valves to clear them of iron flocs and sand, and wash their hands prior to handling the ART media, valves, etc. The container used for transferring raw water into the ART should be kept clean, the lid on the top bucket replaced as soon as the user is finished transferring raw water into the ART, and general good hygienic practices should be followed The household members should flush the media with boiling water or bleach solution immediately in response to complaints or if results of the sanitation survey suggest contamination of the ART	S	As discussed above the household is provided with the O&M manual and appropriate training, including hygiene education
	Aesthetic concerns such as iron, colour, taste, odour, etc. of the treated water	Chemical and physical contaminants	Upon startup, the first 3 or 4 batches that flush the media should be discarded. If the ART has not been used for a few days, the first batch of treated water should be discarded because it may not be aesthetically pleasing	U	As discussed above the household is provided with the O&M manual and appropriate training, including hygiene education

³ Risk type: S = significant, U = uncertain, I = insignificant

Water Safety Plan for SONO Arsenic Removal Technology: Version-1

Process Step (code from pro- forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk ⁴	Additional Control Measures Required to Help Reduce Risk
ART4 Treatment (with arsenic removal technology)	The ART does not perform satisfactorily, and produces treated water with concentrations of As > 50 µg/L due to failure to replace the arsenic removal media as required	Arsenic contamination due to failure to replace media on schedule	Ensure that the ART is operated (including discarding the first three or four batches upon startup to ensure that the media is flushed) and maintained according to the requirements of the SONO O&M manual The media in the two buckets of the SONO filter should be replaced every 6 months or 8,100 litres of treated water produced (whichever comes first), as per the deployment conditions in the technology verification certificate.	S	As discussed above the household is provided with the O&M manual and encouraged to monitor the date regularly to identify when the media requires replacement
ART5 Collection of treated water	Collect water in unsanitary container	Microbial (B,V,P)	Clean and/or disinfect water container regularly with ash (Bangladesh rural context), detergent or soap, and rinse well with clean water.	S	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation
	The collector does not practice good sanitary practices (such as dipping his/her fingers into collected water, etc.)	Microbial (B,V,P)	Ensure that vessel is put close to the ART outlet spout to allow direct entry of water into the collection container and to ensure that water does not come into contact with any possible sources of contamination such as hands, utensils, etc. Also, sanitize the tap and outlet spout regularly to keep it clean and free from contamination	S	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation
ART6 Transport of water	Water becomes contaminated during transport in an uncovered container	Microbial (B,V,P)	If the ART is not located and operated immediately in the household, and treated water must be transported from the ART to the household, ensure that the vessel has a cover that is used during transport	U	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation
ART7 Storage	Water becomes contaminated during transfer of water from transport container into a contaminated storage container	Microbial (B,V,P)	Clean and/or disinfect storage container regularly with ash (Bangladesh rural context), detergent or soap, and rinse well with clean water, and ensure that water does not come into contact with possible sources of contamination such as contaminated utensils and unclean hands	S	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation
	Water becomes contaminated from people, animals, insects or airborne dust while in storage at the home	Microbial (B,V,P)	Keep the storage container covered at all times and store water container at elevated levels	S	Provide hygiene education to the household members
ART8 Use	Water becomes contaminated because unsanitary cups or utensils are used to collect water from the storage container	Microbial (B,V,P)	Clean and disinfect dipper cup that is used to withdraw water from storage container, or tip the storage container to pour water directly into the drinking vessels	S	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation

⁴ Risk type: S = significant, U = uncertain, I = insignificant

Water Safety Plan for SONO Arsenic Removal Technology: Version-1

Process Step (code from pro- forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk⁵	Additional Control Measures Required to Help Reduce Risk
ART8 Use	Water contaminated before consumption because unsanitary drinking utensils used, or unclean hands	Microbial (B,V,P)	Use clean cups and utensils, and practice good hygiene	S	Provide hygiene education to the household members, stressing the importance of cleanliness and sanitation
ART9 Waste Management	Arsenic from wastes is released into the environment in significant amounts	Environmental pollution	Ensure proper management of arsenic-containing wastes, including exhausted media, sludge and precipitate, etc.	I	Ensure that waste management instruction is provided in the O&M and through training - a follow-up program to monitor the effectiveness of the training is recommended

⁵ Risk type: S = significant, U = uncertain, I = insignificant

Table 7. Operational monitoring schedule.

Process Step	Performance Indicator	Monitoring	Critical Limit	Corrective Action	Supporting Programs
ART1 Source (tubewell)	Quality of groundwater used for ART	<p>What: Inspection and screening of tubewell Tests for manganese and other key chemicals (<i>note: not including arsenic and iron</i>)</p> <p>How: Inspect tubewell Analyse water samples using field test kits and send 5% to analytical lab for confirmation, compare results to requirements</p> <p>When: During well selection, prior to ART installation</p> <p>Who: Provider of ART</p>	<p>Requirements of WSP for tubewells</p> <p>WHO water quality guidelines</p>	<p>What: If tubewell not in compliance, move to an alternative tubewell or safe drinking water source</p> <p>How: Through on-going source water selection process</p> <p>When: During well selection, prior to ART installation</p> <p>Who: Provider of ART</p>	<p>Develop local capacity to identify and inspect tubewells and conduct field analyses following SOPs, QA/QC, etc.,</p> <p>Develop local analytical lab capacity</p>
ART1 Source (tubewell)	SONO ART is appropriate for the tubewell	<p>What: Ensure that concentrations of arsenic, iron and phosphate comply with the deployment conditions for the SONO ART</p> <p>How: Analyse water samples using field test kits and send 5% to analytical lab for confirmation Compare results to SONO deployment conditions attached with the Verification Certificate</p> <p>When: Prior to installation of ART</p> <p>Who: Provider of ART</p>	<p>Concentrations of key parameters outlined in deployment conditions of the ART Verification Certificate:</p> <ul style="list-style-type: none"> • arsenic ≤ 750 µg/L • iron ≤ 10 mg/L • phosphate ≤ 4 mg/L • pH ≤ 7.5 	<p>What: If the SONO ART is not appropriate for the tubewell, move to an alternative tubewell or safe drinking water source</p> <p>How: Through on-going source water selection process</p> <p>When: Prior to installation of ART</p> <p>Who: Provider of ART</p>	<p>Ongoing screening and ART awareness programs, develop the local capacity to conduct field analyses following SOPs, QA/QC, etc.,</p> <p>Develop local analytical lab capacity</p>
ART2-ART3, ART5-ART8 Collection, transfer, transport, storage and use of drinking water	Sanitary maintenance of ART, and hygienic water collection, transport, storage and use	<p>What: Inspection of ART and water hygiene practices during the collection, transfer, transport, storage and use of water</p> <p>How: Household sanitary inspection of ART and water handling practices</p> <p>When: Every two weeks</p> <p>Who: Household, with support from community hygiene promoter and/or provider of ART</p>	<p>Good operating practices, and the operating conditions outlined in the SONO O&M manual</p>	<p>What: Repair the ART pipes, taps, etc. when necessary and flush ART with boiling water to sterilize it</p> <p>How: Perform repairs and maintenance to the ART pipes, taps, etc. and pass boiling water through ART to sterilize, according to the O&M manual instructions</p> <p>When: Repair immediately, upon requirement Sterilize according to weekly schedule, each time maintenance is performed, or when necessary as per results of inspections</p> <p>Who: Household</p>	<p>Community hygiene promoters, with support from the community committee, to conduct sanitary inspections and when necessary, provide additional hygiene training</p>

Water Safety Plan for SONO Arsenic Removal Technology: Version-1

Process Step	Performance Indicator	Monitoring	Critical Limit	Corrective Action	Supporting Programs
ART3-ART4 Transfer (water flows from top bucket into lower bucket) and treatment (arsenic removal technology)	Technical performance: ART producing adequate volumes of treated water	<p>What: Regular maintenance of ART and process parameters such as daily volume, flow rate, etc.</p> <p>How: If ART performance is not satisfactory or flow rate is low, measure flow rate and volume of water produced in a day</p> <p>When: Monitor ART performance every two weeks during sanitary inspection, or when a change in performance is observed</p> <p>Who: Household</p>	Process parameter operating values and maintenance schedule specified in the SONO O&M manual	<p>What: Restore ART unit performance</p> <p>How: As per the O&M manual, wash top layer of ART media, use a clean sewing needle to pick any sand and iron flocs out of the valves, etc.</p> <p>When: Conducted as per the schedule in the O&M manual, and when poor performance is observed</p> <p>Who: Household</p>	Household is provided with a SONO O&M manual and appropriate training Community hygiene promoter or NGO inspect O&M schedule and practices and provide additional training if necessary
ART3-ART4 Transfer (water flows from top bucket into lower bucket) and treatment (arsenic removal technology)	Proper ART-specific maintenance and hygienic practices	<p>What: Frequency of maintenance activities such as flushing the ART with boiling water and replacing the sand filter in the top bucket</p> <p>How: Conduct survey on 10% of ARTs throughout the deployment area and review household records (if available) to compare results to the schedule that is outlined in the O&M manual</p> <p>When: Inspections and review of the results on a semi-annual basis for select units</p> <p>Who: Maintenance conducted by household, review conducted by NGO or other organisation that provided the ART</p>	Maintenance schedule, as outlined in the ART-specific O&M manual	<p>What: Perform ART maintenance and strengthen the importance of O&M</p> <p>How: Flush the ART and replace sand filter media regularly and as necessary Provide the household with appropriate follow-up training to emphasize the importance of regularly scheduled O&M</p> <p>When: When inspection results indicate that the ART is not being maintained according to the O&M manual</p> <p>Who: Maintenance conducted by household, review and training support by NGO or other organisation providing the ART</p>	On-going training, as necessary, for household members
ART3-ART4 Transfer (water flows from top bucket into lower bucket) and treatment (arsenic removal technology)	Control of Aesthetic Water Quality	<p>What: Aesthetic quality of treated water</p> <p>How: Inspection and discussion amongst household members</p> <p>When: Every two weeks, during sanitary inspection</p> <p>Who: Household</p>	Acceptable aesthetic water quality, as indicated by end-users	<p>What: Restore ART unit performance</p> <p>How: If ART has not been used for a few days, treat a batch of water and discard to flush the media Replace sand filter media as required</p> <p>When: Replace the sand media every 4-6 months, or when flow is noticeably slower, and discard batch of treated water when poor aesthetic water quality is indicated by end-users</p> <p>Who: Household</p>	Household members are provided with an ART-specific O&M manual and appropriate training

Water Safety Plan for SONO Arsenic Removal Technology: Version-1

Process Step	Performance Indicator	Monitoring	Critical Limit	Corrective Action	Supporting Programs
ART4 Treatment (arsenic removal technology)	Technical performance: proper replacement of ART media	<p>What: Replacement of ART media according to schedule</p> <p>How: Check calendar to identify when ART media should be replaced</p> <p>When: Calendar checked monthly Media replaced every six months or when 8,100 litres of treated water are produced (whichever comes first)</p> <p>Who: Household</p>	Deployment conditions in the ART Verification Certificate – every six months or 8,100 litres of treated water produced	<p>What: Replace the SONO ART media</p> <p>How: Contact the proponent to arrange for replacement media for the SONO ART</p> <p>When: When the media has been used for 6 months, or when 8,100 litres of treated water have been produced</p> <p>Who: Household</p>	<p>Provide education and motivation training to the household on the deployment conditions and media replacement requirements</p> <p>Maintain up-to-date contact information for the SONO proponent</p>
ART9 Waste management	Compliance with waste management requirements	<p>What: Appropriate disposal of arsenic-containing wastes from the ART (exhausted media)</p> <p>How: Observe media replacement activities, inspect activities and ensure that proponent collects spent media and removes it from the site</p> <p>When: When the media is replaced</p> <p>Who: Household</p>	Waste management requirements in the ART verification certificate	<p>What: Have proponent remove spent media from the site</p> <p>How: Contact proponent to arrange for the media to be collected</p> <p>When: If necessary, when spent media identified</p> <p>Who: Household</p>	<p>Provide the household with information on media replacement requirements</p> <p>Promote DPHE involvement in the process if required</p>

Table 8. Verification schedule.

Activity	Description	Frequency	Responsible Party	Records
Effectiveness of water safety management	Scheduled meetings with WATSAN committee, community committee, and end-users	Semi-annual visits	NGO or ART provider, in coordination with DPHE	Information to be maintained by NGO or ART provider (the local level), and supplied to DPHE (the national level)
Tubewell inspection	At source selection, inspect tubewell according to the tubewell WSP requirements	During tubewell selection, prior to selecting and installing ART	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Testing concentrations of arsenic	Routine well characterisation and monitoring data from 5% of the SONO ARTs is collected using filed test kits (with 5% of the samples going to a lab that is suitable to DPHE for confirmation), compiled and analysed to verify the performance of the well selection procedures and the performance of the ARTs	Source: during tubewell selection, to coincide with tubewell inspection ARTs: on a select sample of SONO ARTs throughout the deployment areas	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Testing of microbial water quality	Sanitary inspection and thermotolerant coliform analysis on 5% of the tubewells and ARTs using either field kit (DelAgua, Potatest, etc.) or a laboratory that is suitable to DPHE Confirmatory testing for <i>E.coli</i> on 5% of samples that test positive for thermotolerant coliform	Source: during tubewell selection and annually on a random selection of tubewells throughout the deployment area ARTs: semi-annual sampling on a random selection (5%) of SONO units	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Sanitation and Hygiene Inspections	In conjunction with the microbial testing (5% of the ARTs), inspection of all major hazardous events that may occur due to poor ART operation and maintenance, and poor hygienic practices by household members	Source: during tubewell selection, and annually on a random selection of tubewells throughout the deployment area ARTs: semi-annual sampling on the random selection (5%) of SONO units that are analysed for microbial water quality	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)

Water Safety Plan for SONO Arsenic Removal Technology: Version-1

Activity	Description	Frequency	Responsible Party	Records
Testing of chemical water quality	Phosphate, manganese, nitrate and iron analyses using field test kits (Hach or equivalent) on 5% of the tubewells and ARTs, with a minimum of 5% samples also submitted to a lab that is suitable to DPHE for confirmation	Source: during tubewell selection, and in response to complaints ARTs: semi-annual sampling on the random selection (5%) of SONO units throughout the deployment areas, in conjunction with the microbial sampling	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Survey of physical water quality	Survey of aesthetic and physical water quality parameters - smell, turbidity, colour, taste, etc.	Source: during tubewell selection, and in response to complaints ARTs: on installation and in response to either complaints or the results of the semi-annual surveys and/or sampling	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Inspection of waste management practices	Survey households to ensure proponent collected wastes as per verification certificate responsibilities Proponents to produce annual reports of waste management practices	ARTs: conducted during the semi-annual visits to SONO ARTs	NGO or ART provider, in coordination with DPHE Annual reports produced by proponents and available for NGOs and Government of Bangladesh as required	Information to be maintained by NGO or ART provider (the local level), and supplied to relevant Government of Bangladesh (the national level)

Note: The verification tasks identified in Table 8 are the joint responsibility of NGOs and other organisations providing the ARTs, and DPHE. Therefore, coordination between the ART providers and DPHE is necessary to gather the information necessary to continually verify the different components of the WSP.

Table 9. Validation schedule.

Process Step	Hazardous Event	Validation
All processes	Introduction of pathogens and presence of arsenic and other pollutants	Use of verification data in quantitative health risk assessment model to assess changes in potential disease burden
Source tubewell	SONO ART is not appropriate for the tubewell water quality, as discussed in Table 6	Analysis of well inspection data and tubewell water analyses from verification, and comparison to SONO deployment conditions outlined in the Verification Certificate to assess whether source well selection measures have been effective and the tubewell water contains water with concentrations of arsenic, iron and phosphate that are suitable for a SONO ART, and is otherwise safe (for manganese, boron, etc.)
ART treatment	Poor operation and maintenance of the ART, leading to unsafe concentrations of arsenic and other chemical and microbial contaminants, and poor aesthetic quality of treated water via hazardous events identified in Table 6	ART Verification Certificates confirm that ARTs consistently produce arsenic-safe water, when operated and maintained according to the proponents' protocols, at appropriate tubewells Review of O&M records and practices, analytical results of treated water samples, and sanitary inspection data from verification to assess whether O&M and hygiene training have been effective
Post source	Introduction of microbial pathogens due to unsanitary practices during collection, transport and storage of water, as discussed in Table 6	Analysis of water quality data and results of sanitary inspection data from verification to assess whether hygiene education has been effective
Waste Management	Inappropriate disposal of ART wastes	Review waste management records to ensure proper disposal practices are followed

Note: The validation tasks identified in Table 9 are the joint responsibility of NGOs and other organisations providing the ARTs, and DPHE. Therefore, coordination between the ART providers and DPHE is necessary to gather the information necessary to continually validate the different components of the WSP.

Table 10. Improvement action plan.

Issue Identified		Action Required	Procedures or Records?	Responsibility	Time Frame	Status
No.	Issue					
1	Source water quality	Inspect the tubewell to ensure that it is in compliance with the requirements of the WSP for tubewells, collect analytical samples of the tubewell water to confirm that it complies with WHO drinking water quality guidelines, and review the data for key water quality parameters to ensure that the tubewell is appropriate for the SONO ART	Follow tubewell WSP requirements, WHO drinking water quality guidelines, and deployment conditions in the SONO ART Verification Certificate	NGO or organisation providing ART, in coordination with DPHE	Short - Long	
2	Safe operation and maintenance of ART	Household is provided with O&M manual and given adequate training to ensure that the ART is operated and maintained properly	Follow the requirements of the O&M manual that is provided with the SONO ART	NGO or organisation providing ART, in coordination with DPHE	Short - Long	
3	Ensure safe water handling post source	Develop guidelines and provide hygiene and sanitation education program to household members to ensure safe water handling during collection, transport and storage – the program should include follow-up visits	Follow guidelines for hygiene and sanitation	VBO members and NGOs responsible for undertaking hygiene education programme	Short - Long	
4	Ensure safe disposal of wastes	Manage wastes as per the GoB requirements	Follow standard procedure for management of wastes for a technology	ART proponent	Long	