FINAL REPORT for APN PROJECT

Project Reference Number: CBA2011-14NSY-Ng

Water Safety from Source to Tap – Strategies and Implementation

- Making a Difference –

Scientific Capacity Building & Enhancement for Sustainable Development in Developing Countries

Water Safety from Source to Tap – Strategies and Implementation

Project Reference Number: CBA2011-14NSY-Ng
Final Report submitted to APN

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

Safe water supply is a major issue worldwide especially with the changing trends influenced by climate change. This issue is particularly critical in developing nations when there are limited resources that would require the need of putting in place an efficient integrated water resource management policy and regulation. This project, through two workshops, organized in Singapore and Kandy, Sri Lanka have achieved capability building by transferring valuable sustainable strategies on water resource management between Singapore and Sri Lanka, as well as the technical knowledge in water treatment technologies and water quality assessment. The workshops also provided training on the development and implementation of Water Safety Plan (WSP) which is viewed as an important risk based assessment tool to evaluate and ensure safe water supply from source to tap. This workshop has also raised awareness on the importance of WSP to the higher management level and have brought together the local expert members and water supply authority to work towards sustaining good and safe water supply to Sri Lanka. The project team has also identify areas for further collaborations from these two workshops.

Objectives

The main objectives of the project were:
(1) Exchange of valuable ideas and to translate sustainable strategies on water resource management between Singapore and Sri Lanka to meet the increasing water demand; and
(2) Capacity development in Sri Lanka in terms of scientific knowledge and transfer of technology from Singapore to Sri Lanka related to sustainable water treatment technologies, water quality assessment and emerging contaminants detection to ensure deliverance of safe water.

Amount received and number years supported

The Grant awarded to this project was:
US$30,000 for Year 1.

Activity undertaken

Two workshops were conducted:
1. Workshop 1 was held at National University of Singapore from 19 - 22 Sept 2011. The workshop covered:
   a. Information sharing and provided a learning platform between Singapore and Sri Lanka teams with invited speakers from National Environment Agency, Public Utilities Board, Ngee Ann Polytechnic and Analytical Laboratories (S) Pte Ltd. The presentations covered water management practices, treatment processes in treatment plants, applications of advance technologies for water and water reclamation, and disinfection technology, catchment management and challenges in pollution control, drinking water quality and regulations, water safety plan practice in Singapore's waterworks.
   b. WSP training using Kandy South Water Treatment Plant (KSWTP) as a pilot study for developing safe water management plan. The 11 steps in WSP were discussed using KSWTP as a case study.
   c. Laboratory demonstration and hands on waste quality assessment on detection of water pathogen, namely, *Cryptosporidium* and *Giardia* which the preserved organisms in formalin were spiked into water for the training. Laboratory facilities at the National University of Singapore (NUS) was used.
   d. Site visits to Singapore's Water Treatment, Water Reclamation - NEWater Facility and Marina Reservoir-reservoir in the city, were carried out to provide a better understanding on Singapore's sustainable water management strategies.

The outcome of Workshop 1 are as follows:

- A number of management strategies and technologies in Singapore can be applied in the Sri Lanka's context.

- NWS&DB also understands the importance of public education for water sustainability in managing the water demand. One interesting educational tool that NWS&DB for KS will consider is to include a monthly water consumption chart for each customer's account on the water usage against the national average. This is currently being practiced in the Singapore's billing system and sample bills were provided to the NWS&DB to study the possibility of adapting this to their billings.
- Fish Water Monitoring System is one major technique that NSW&DB would like to implement at KSWTP. However, the fishes used in the monitoring systems would need to be an indigenous species that can be easily found in Sri Lanka and would need to be tested to check for its sensitivity towards potential hazardous contaminants in the raw water and treated water. NWS&BD will work with their local institutions to further develop this technique for their local application.

2. Workshop 2 was held in Kandy, Sri Lanka from 22- 24 Feb 2012. The workshop covered:

a. Technical site visits to the KSWTP, demonstration on wetland systems for pollution control and site visits to the KSWTP catchment area. These site visits established a better understand on the site conditions and operation understanding to develop the WSP for KSWTP and also the use of natural systems for reducing the pollution load to the environment.
b. A follow up discussion on the WSP development for KSWTP to establish the approach and strategies for implementation.
c. Information sharing on the management and treatment technologies, pollution evaluation and monitoring in assessing the risks to safe water supply.
d. A short workshop on WSP Quality Assurance Tool as an assessment and reporting tool on WSP implementation.

The outcomes of the Workshop 2 are as follows:

- Piloting the development of a full scale WSP for KSWTP in Sri Lanka with the assistance from experts from academia of different disciplines. The WSP document will be used as a model to develop WSPs for other major water treatment facilities,
- School program has been initiated by involving school children in the development and implementation activities of WSPs for their school water supply systems as a learning tool under the awareness program funded by UNICEF,
- Development of standard mitigation programs for catastrophic epidemical situations; the hazard identification and implementation of control actions were developed based on the experiences enhanced from the APN project for the recent incident happened at Thalawakele, Sri Lanka due to dysentery because of rotavirus,
- Hazard identification in the catchment area has initiated a program on monitoring the health impact of disinfection by-products (trihalomethane) in the KSWTP served area as a collaborative project with the University of Peradeniya, Sri Lanka for the first time to implement a water distribution system management program,
- Characterization and quantification of pollution load from the dump sites (Gampola and Guhagoda) along the Mahaweli river bank on their impact on water quality and develop proposals for future control actions,
- Conduct awareness program with organizations such as Ministry of Health, local authorities and community based organizations, and installation of small water supply facility that does not require extensive knowhow and technical experiences.

Results

This project has achieved transfer of technical and management strategies between Singapore and Sri Lanka to develop a more sustainable water management strategies. The workshops had also established a platform to bring together experts and pull together available resources in Singapore and Sri Lanka to provide and enabled a better water management from source to tap.

Capability building established from this project is being disseminated through workshops namely, WSP training workshops within the NWS&DB to provide an understanding to the officials on the importance of WSP and on the development and implementation of WSP to the water supply and treatment facilities. WSP training has also been incorporate as part of the course module for the undergraduate and postgraduate training at University level.

This project has created awareness at higher management levels of NWS&DB on the importance of the WSP and other management strategies and related treatment and assessment technologies through the dissemination of the summary reports following the workshops.

This project has initiated the development of WSP for KSWTP and further identified areas of improvement and implementation that could enhance the continuous supply of safe water. Through this workshop, a WSP team known as "Task force" comprises members of KSWTP officials and an Expert Panel made up of relevant expertise from academia and stakeholders have been set up. The Expert Panel is to serve as advisory to the WSP team and also an independent external auditor to provide regular review on the WSP process. This would increases the integrity of the WSP and also enhance the stakeholders and consumers' confident on the water supply being delivered by the KSWTP.

Relevance to the APN Goals, Science Agenda and to Policy Processes

This project had provided a platform for management and technical information sharing on mitigation and adaptation in water resources, treatment and supply strategies under climate change conditions. Capacity building in terms of hands-on detection techniques on emerging contaminants and micropollutants in the water to establish quality assurance in delivering safe water together with establishing and implementing the WSP would strongly enhance the target of having safe water to the consumers. The workshops conducted in Singapore and Sri Lanka involved tertiary and research Institutions, professionals and government agencies. The activities had created awareness among the high ranking administrative officials which have successfully communicated the importance of putting in place a Water Safety Plan to ensure the deliverance of Safe Water from Source to Tap using Kandy South Water Treatment Plant as a case study. The WSP from this case study is a pilot project that establishes a risk based preventive approach and also as an assessment and reporting tool to the management, decision and policymakers on the best management of the water and related resources.

Self evaluation

The project has provided a platform for information and technical sharing. In addition, the workshops have also helped to identify strategies and technologies that can be translated from Singapore to Sri Lanka for an improved water management system. This project has provided a platform to consolidate valuable resources from different institutions within Kandy and concerted effort in enhancing the water quality assurance, water treatment technologies and management strategies in providing safe water. The training from this project has pushed forward the development of a preliminary WSP document for the KSWTP, which is a pilot case study in Sri Lanka.

Potential for further work

A WSP for the KSWTP has been developed and further collaborative and integrated effort to continuously improve the WSP is on-going. The technical strength and expertise from various organizations and institutions are being explored such as expert advisory, and analytical expertise and resources to have more comprehensive water safety management and assurance.

The Singapore and Sri Lanka teams have identified areas on information sharing and further technical collaborations in catchment management, water treatment technologies and quality assessment.

Publications (please write the complete citation)

1. Development of Water Safety Plan for Kandy South Water Treatment Plant, Sri Lanka - A Case Study on Approach and Strategy. Lee L.Y., Weragoda S.K., Ng H.Y., Attanayake M.A.M.S.L., Hu J.Y., Manatunge J., Herath G., Mowjood M.I.M., Jinadasa K.B.S.N., Weerasooriya R., Vithanage M., Kalpage C.S.,Ong S.L., Lim H.S. and Makehelwala M. Singapore International Water Week 2012, 1- 5 July 2012, Singapore (Accepted for poster presentation).

2. Water Safety Plan on Kandy South Water Treatment Plant - from Source to Tap. Management Document, National Water Supply and Drainage Board, Sri Lanka (in preparation)

3. Development of Water Safety Plan in Sri Lanka using Kandy South Water Treatment Plant as a pilot case study. Targeted for submission to Water Science and Technology: Water Supply (In preparation).

Acknowledgments

The project team would like to thank the World Health Organization for providing the materials on Water Safety Plan, especially to Ms Mien Ling Chong and Ms Jennifer Defrance of WHO for sharing their expertise and providing their support on Water Safety Plan training.

The project team would also like to acknowledge the technical support, training and sharing of experience provided by:

Workshop 1: Ms Xiaolan Tan and Ms Xiaona Chu from National University of Singapore, Mr Jonathan Goh from Analytical Laboratories (S) Pte Ltd, Dr Pranav Joshi and Ms Lam Chun Hsiang from National Environmental Agency, Singapore, Mr Sathananthan Selvadurai from Ngee Ann Polytechnic, Dr Lim Mong Hoo and Mr Woo Chee Hoe from Public Utilities Board Singapore.

Workshop 2: Prof S.B.S Abayakoon , Vice Chancellor, University of Peradeniya and Mr Karunasena Hettiarachchi, Chairman, National Water Supply and Drainage Board.

Lastly, the project team is grateful to the collaborating organizations/institutions: Environmental Engineering Society of Singapore, National University of Singapore, National Water Supply and Drainage Board, University of Moratuwa, University of Peradeniya and Institute of Fundamental Studies in making this a successful project.

TECHNICAL REPORT

Preface

Climate change has increased the challenges in providing sustainable safe water supply in addition to the population increase. This project has engaged scientists and technical personnel from Singapore and Sri Lanka and water authorities to establish a platform for information sharing and capacity building on water management strategies, treatment technologies and assessment tools for sustainable water management. Possible translation and adaptation of management strategies, treatment and assessment tools for application in Sri Lanka have been identified. Water Safety Plan training has also provided the basis for developing the preliminary Water Safety Plan (WSP) for the Kandy South Water Treatment Plant (KSWTP) which is the pilot case study for Sri Lanka to ensure the deliverance of safe water supply under variable water sources qualities and quantities.

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Background

Climate change leading to extreme droughts, floods caused by excessive rainfall and increasing sea levels leading to salt intrusion into freshwater, are reducing the reliability of natural water sources. These together with growing population especially in developing countries such as Sri Lanka, are challenges faced by water supply authorities. As currently practiced in Singapore, a country with limited raw resources, integrating watershed management with energy and water efficient treatment and reclamation technologies could provide a holistic approach to meeting these challenges and providing safe water through stringent water quality assessment. There are numerous geographical and climatic similarities between the Asia region countries, Singapore and Sri Lanka - both are island-countries surrounded by seawater and subjected to hot and arid weather conditions. These are major factors for successful intra-regional technology transfer and possible adaptation of water management strategies including source water quality assessment to ensure deliverance of safe water. This project involves Singapore for transfer of technologies on water management and scientific expertise development to Sri Lanka and vice versa.

Objectives

This project aims to achieve: (1) exchange valuable ideas and to translate sustainable strategies on water resource management between the two Asia region countries, Singapore and Sri Lanka, to meet the increasing water demand; and (2) capacity development in terms of scientific knowledge and transfer of technologies related to sustainable water treatment and energy recovery, water quality assessment and emerging contaminants detection at national level to ensure deliverance of safe water.

2.0 Methodology

The project was carried out through the following mode:

(1) Background and information sharing, and technical sharing through 2 workshops.

Workshop 1 was held in Singapore from 19 - 22 Sept 2011 to initiate the project: covering review on water resource management in Sri Lanka and Singapore; sampling techniques, hands-on water assessment and analytical techniques; and case studies using the KSWTP as a pilot study for developing safe water management plan. Laboratory facilities at the National University of Singapore (NUS) were used for the training.

Workshop 2 in Kandy Sri Lanka was held from 22 - 24 Feb 2012 and tailored to address focused areas following the Workshop 1. Follow-up discussion and review on the establishment and implementation of the management plan at the KSWTP were carried out. Site visits to the KSWTP provided an insight of the operation of the plant; catchment area of KSWTP provided a better view on the catchment management challenges and the consumers' end which is lacking of infrastructure for continuous water supply;

The workshops conducted in Sri Lanka and Singapore provided management and scientific knowledge, and technology transfer within the region.

The Water Safety Plan developed was based on World Health Organization Water Safety Plan Manual: Step-by-step risk management for drinking-water suppliers (Bartram *et al*., 2009).

(2) E-conferences and e-mail communications had to facilitated information sharing and discussion, data analysis, and discussion on joint collaborations and joint papers results from this collaboration.

The first E-conference was held on 18 July 2011 between the Singapore and the Sri Lanka team members to get to know each team members, to discuss the details of the project and Workshop 1 program as well as to work out the logistics for Workshop 1.

Subsequent e-mail communication was the main mode to consolidate the presentation materials, to confirm the logistic arrangements prior to the workshop, information sharing on targeted areas, discussion on joint collaborations and finalizing joint papers.

(3) Dissemination plan:

The Singapore and Sri Lanka team reviewed the means of disseminating the knowledge gained from this project to wider group for capability building and also to bring awareness on the importance of an intact WSP from source to tap to the policy and decision makers.

Joint papers and reports, together with in-house training and incorporating into the undergraduate and postgraduate courses are part of the dissemination tools.

Among them, a joint paper on "Development of Water Safety Plan for Kandy South Water Treatment Plant, Sri Lanka - A Case Study on Approach and Strategy" by Lee L.Y., Weragoda S.K., Ng H.Y., Attanayake M.A.M.S.L., Hu J.Y., Manatunge J., Herath G., Mowjood M.I.M., Jinadasa K.B.S.N., Weerasooriya R., Vithanage M., Kalpage

C.S.,Ong S.L., Lim H.S. and Makehelwala M, has been accepted for poster presentation at the Water Convention at Singapore International Water Week 2012, which will be held from 1-5 July 2012.

In addition, the team is currently preparing a joint paper for possible journal publication and the WSP for the KSWTP as a Management Document for the NWS&DB, Sri Lanka.

3.0 Results & Discussion

(1) Information sharing and technical sharing through workshops and e-communications.

The activities in this project has also raised awareness among scientists, academia and water authority on the importance of watershed management, treatment technologies and water quality assessments as integrative tools, and the available options in management and technologies to achieve best practice in providing safe sustainable water supply.

In addition, one of the major factors that contributed to Singapore's water management success is public education and public a major stakeholder in sustaining water resources. These are valuable information that forms the structure for developing a safe water management plan in Sri Lanka. The NWS&DB, Sri Lanka, plays an important role in applying these factors effectively as decision making tools and translate to the relevant policy-makers to formulate a sustainable resource management and development plan for the country using the WSP developed for the KSWTP as a pilot demonstration case study.

Management practice and technologies for potential application in Sri Lanka

1. Fish Water Monitoring System is one major technique that NSW&DB would like to implement at the KSWTP. However, the fishes used in the monitoring systems would need to be a indigenous species that can be easily found in Sri Lanka and testing has to be carried out to check for its sensitivity towards potential hazardous contaminants in the raw water and treated water. NWS&BD is working with local institutions to further develop this technique for local application.

2. NWS&DB also understands the importance of public education for water sustainability in managing the water demand. One interesting educational tool that NWS&DB for KS is considering is to include a monthly water consumption chart for each customer's account on the water usage against the national average. This is currently being practiced in Singapore's billing system and sample bills were provided to the NWS&DB to study the possibility of adapting this to their billings.

3. NWS&DB has indicated interest in the bioretention systems which is currently used in the managing of stormwater quality in Singapore for potential implementation in Sri Lanka. Discussion is being carried out between Singapore and Sri Lanka team for further collaboration in this area.

(2) Development of WSP for KSWTP

Background on the KSWTP:

The KSWTP was commissioned on 29th January 2010. The main responsibility of this plant is to treat raw water abstracted from the Mahaweli Ganga (River) and supply the treated water to 15 reservoirs located in the service area, i.e., South to the Kandy Metropolitan area. This plant is designed to produce 35,000 m^3/day of drinking

water compiling to the SLS standards (Ordinance of SLS standard 614: Part 1 & 2) (Sri Lanka Standards Institute, 1985). It is expected to serve 250,000 numbers of consumers before the design horizon of year 2030. The current water demand is only at 60% of its designed capacity. The water treatment facilities comprise: 1) Intake section, including the Mahaweli River with impound weir, coarse and fine screen; intake well with submersible pumps and sludge removal pumps; 2) Treatment processes, including aerator, lime and alum feeding, pre-chlorination, pulsators, sand filters, backwashing system, post chlorination and neutralization system; 3) Storage, including high lift pump house; 4) Sludge Treatment; and 5) Other accessories, including supervisory control and data acquisition (SCADA), programmable logistic controls (PLCs) and radio systems.

Currently, there is no legislation set in Sri Lanka related to the establishment of WSP or any other management tools for monitoring drinking water quality and continuous supply of safe water. Further, acquiring ISO 9001 certification is also not a compulsory requirement. Hence, the management has decided to use WSP as the best option to ensure continuous supply of safe water in this regards.

Organization of the KSWTP:

The KSWTP is managed by the Production Manager of Regional Support Centre-Central, who reports to the Deputy General Manager of the central province. The day-to-day operation of the KSWTP is carried out by the Plant Engineer with 11 staff members (Figure 1).

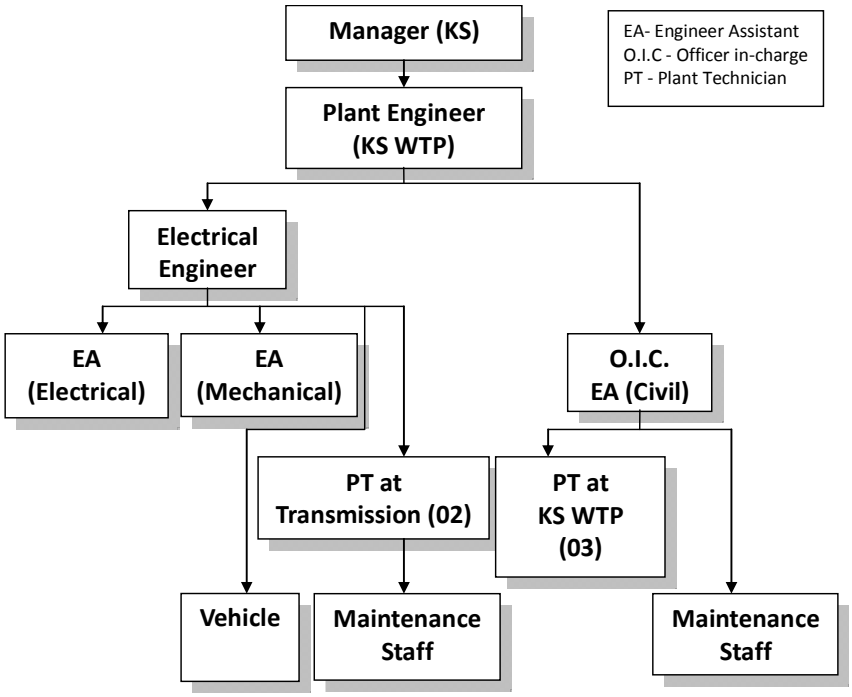


Figure 1. Organization chart of the KSWTP management and operation.

Approach to the WSP development and implementation for the KSWTP

Initial WSP training was conducted in Workshop 1 in Singapore 2011 to provide the knowledge on developing the WSP for the KSWTP using the World Health Organization (WHO) 11-Steps Guidelines (Figure 2). This initiated the preliminary planning on the development of WSP. This knowledge was subsequently dissemination by the

Sri Lanka team to the operation and management staff of the KSWTP to further establish a working strategy to fully develop and implement the WSP. In Workshop 2, these strategies were discussed and reviewed. A summary of the WSP for the KSWTP is given as follows:

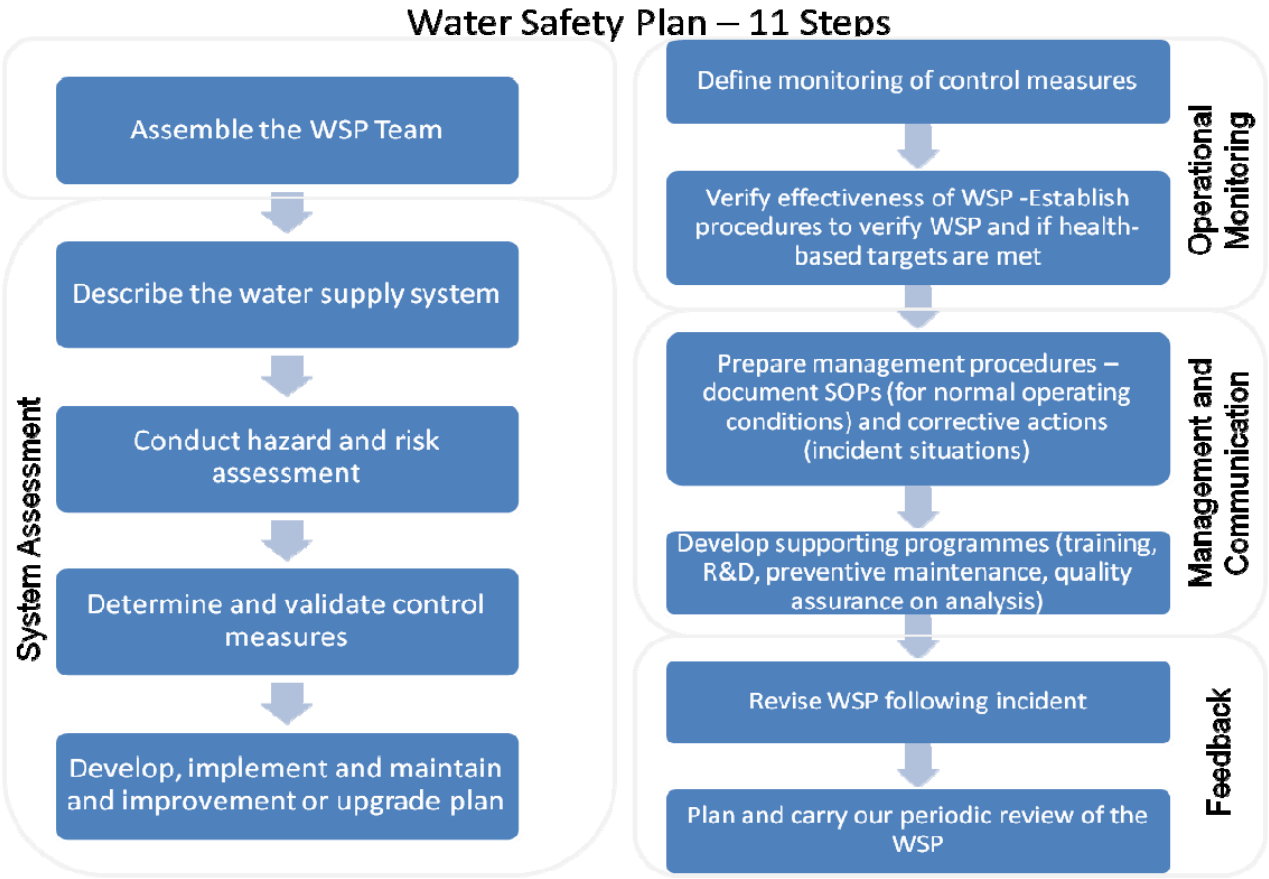


Figure 2. Development and Implementation of a Water Safety Plan - 11 Steps (Bartram et al., 2009).

WSP Development

This project has initiated the development and implementation of the WSP for the KSWTP through establishing the appropriate working strategies and initiated the WSP development:

1. Assembling Teams:

A qualified and dedicated team is mandatory to engage the technical expertise required for a successful WSP development and implementation. WSP teams can comprise of *Core Team* who plan, develop, implement, maintain and update the WSP; *Specialist or Subordinate Working Team* who manages a division of the water supply system such as catchment, treatment and distribution systems; and *External Teams or Reviewers* such who are representatives from government and regulatory agencies and experts.

In KSWTP case study, the strategy in developing, implementing and maintaining the WSP is carried out through 4 groups (details are provided in Appendix A). Figure 3 illustrates the relation between the 4 WSP groups.

a) *Initiating Group*: The team members comprise the Sri Lanka team members from this project who have received initial training on WSP will form the Initiating Group. This team studied the WSP concept through literature review, initiated the background work for WSP; identified a working plan and identified members for different working teams.
b) *Steering committee: E*stablished to provide political support and to coordinate WSP implementation activities with stake holders.
c) Water Safety Team known as "*Task Force*": Comprised of management, engineers, plant operators and analyst within KSWTP. The team tasks are to develop, improve, maintain and execute the WSP proposed by the Initiating Group through member's technical expertise and work experience.
d) *Expert Panel*: To provide technical advice, carry out training programs based on request and serve as an "Independent Auditor" until the government established a "Regulating Authority".

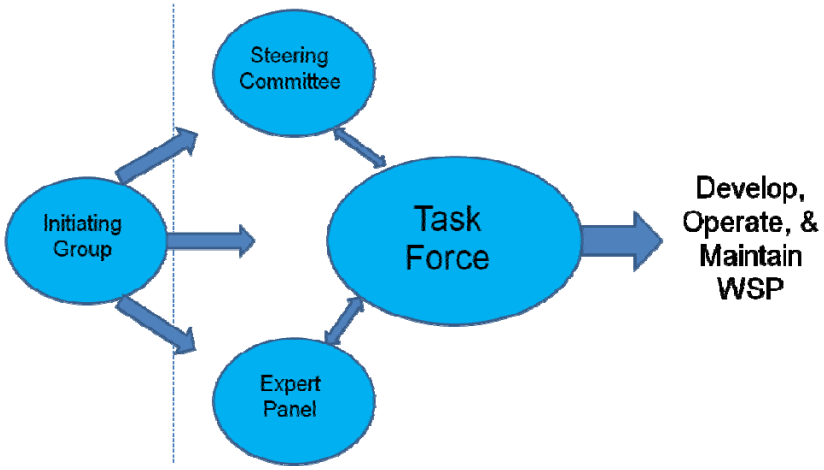


Figure 3. Relation of 4 groups in the WSP for the KSWTP.

The Task Force works closely with the Expert Panel through the 11-Steps of the WHO Water Safety Plan (as illustrated in Figure 2) to establish a working WSP document for the KSWTP.

2. Describe the Water Supply System: Catchment to Consumers' Tap

This WSP step is essential to provide adequate information to identify the type of hazards and hazardous events that could affect the supply of safe water in the water supply system. The water supply system, the KSWTP, is divided into Catchment, Treatment and Distribution. Each subdivision is described in detailed through flow diagrams where ever possible, to understand the water quality issues with reference to the national water quality guidelines, and knowledge on the consumers and uses of the water supplied.

Catchment:

The KSWTP extracts raw water from the longest river in Sri Lanka, known as the Mahaweli River. Its catchment area covers 1/6th of the country land area of 65,610 km^2 (Figure 4). However, the treatment plant has been located in middle stretch of the river. There is a large hydropower generation plant located about 30 km upstream to the WTP. The river passes through many urban and local settlements and therefore its water carries many pollutants coming from urbanized areas (Figure 5). The above description of the KSWTP catchment

provided the information on activities and land use that could contribute potential hazards to the source water. Hazard and risk assessments in the subsequent WSP steps are carried out to evaluate these hazards and to prioritize mitigation actions.

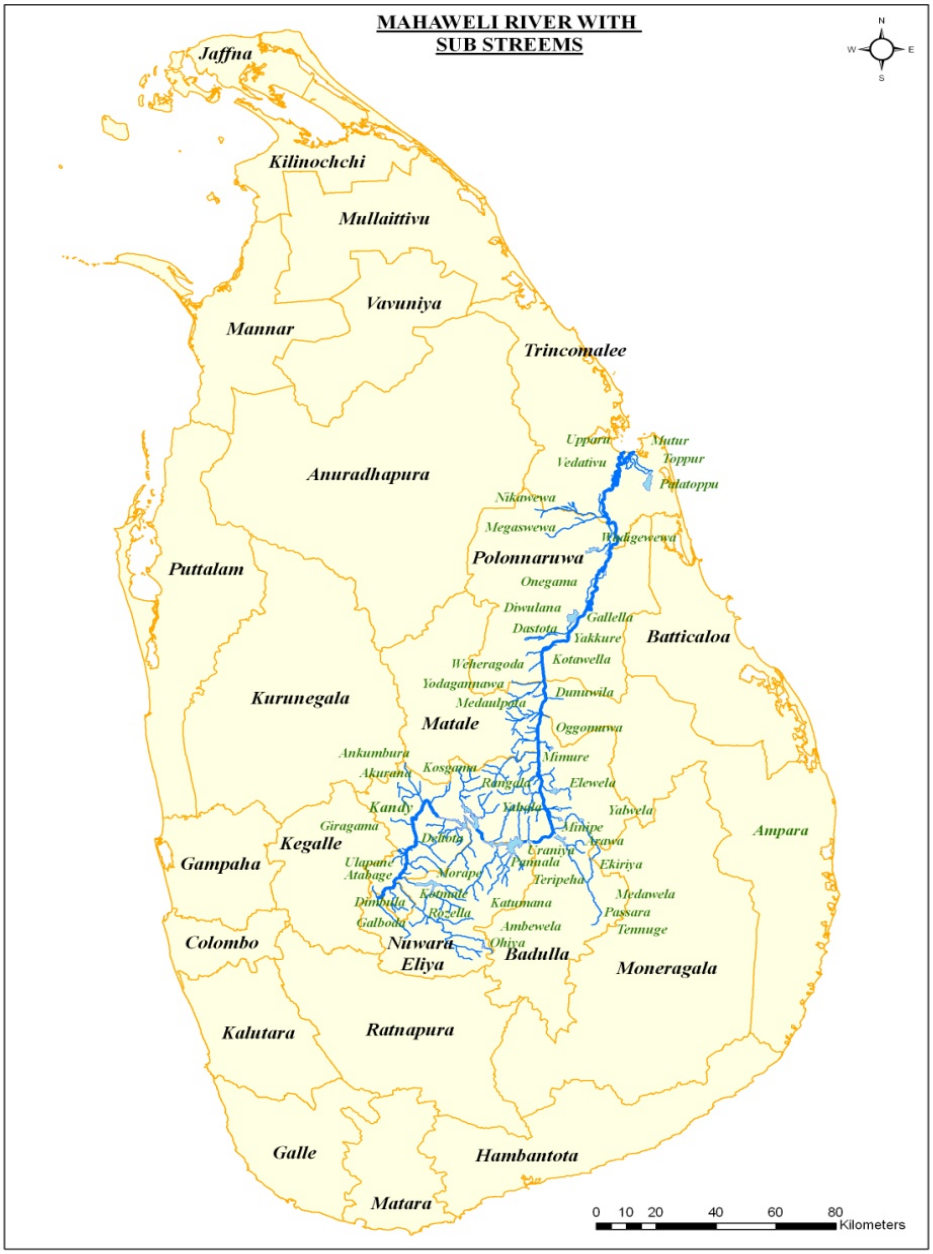


Figure 4. Catchment area of the KSWTP.

Treatment Process:

The KSWTP consisted of a river intake with two bar screeners of 20 and 6 mm openings. River water is pumped to an aerator and sent through two pulsators and six sand filters set in parallel. Alum is used as the coagulant and lime is added as needed. Pre- and post-chlorination is also carried out. Figure 6 shows the river intake and treatment process units at the KSWTP. There are 15 reservoirs and treated water is pumped to 3 levels via 9

booster pumping stations. The full system is controlled by a SCADA system which is connected via radio signals. Online measurements are implemented for raw water pH, turbidity, color and treated water free Cl_2 level. Figure 7 illustrates the KSWTP processes and the SCADA system. The treatment processes provided the step-by-step process and control steps which enable hazards and risks identification that could affect the quality of treated water.

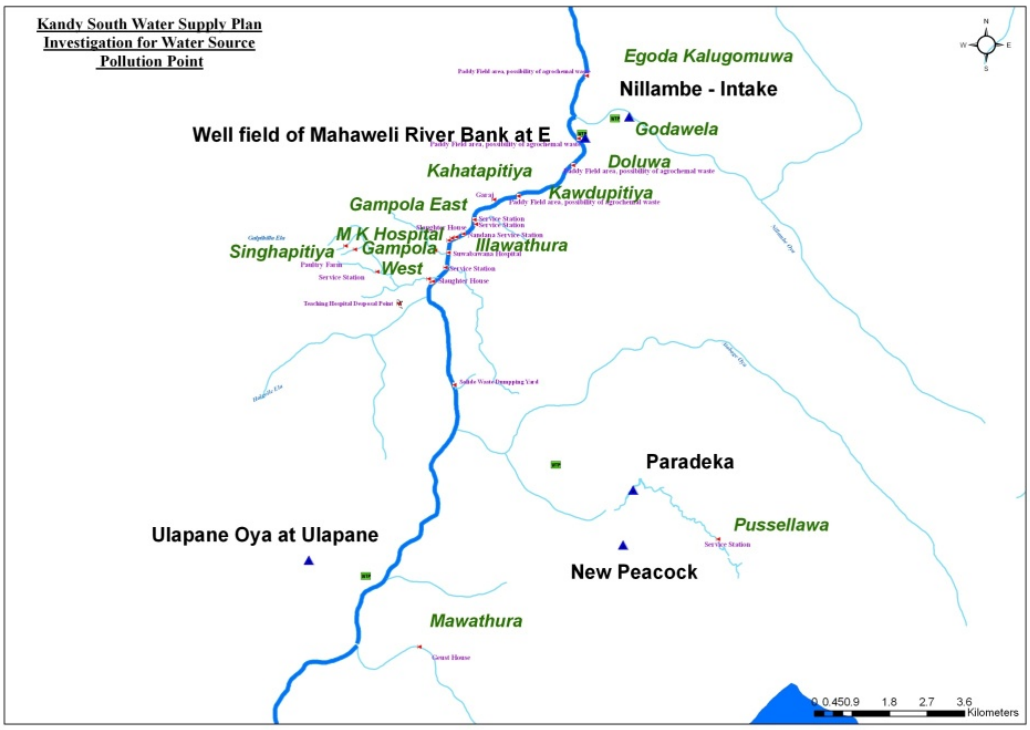


Figure 5: Pollution sources within the catchment area of the KSWTP.

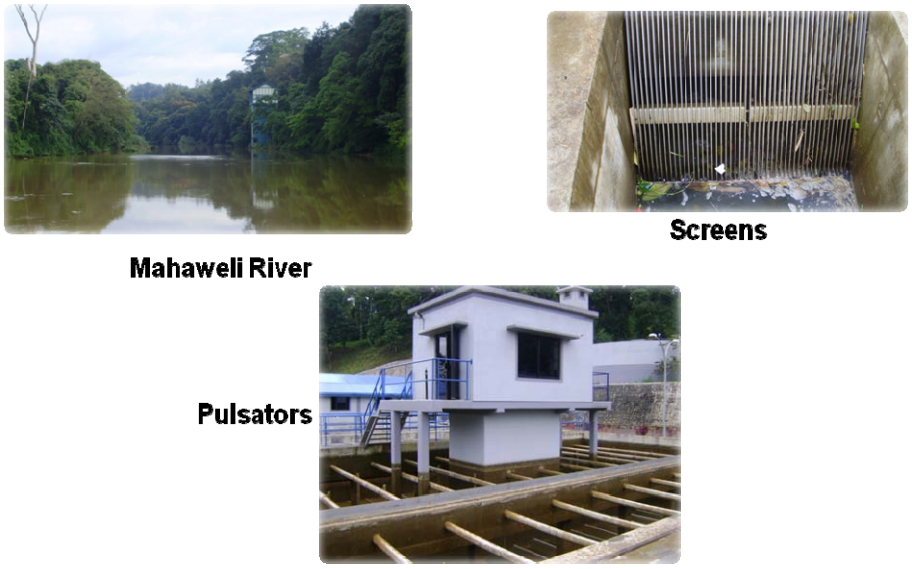


Figure 6. River intake and treatment processes at the KSWTP.

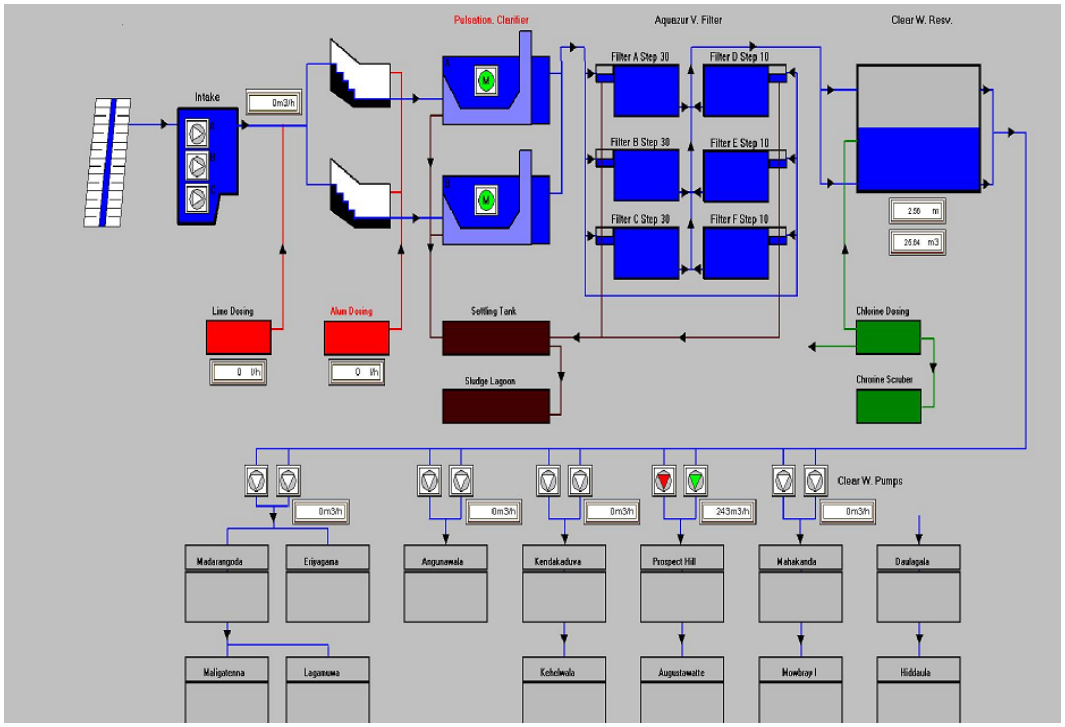


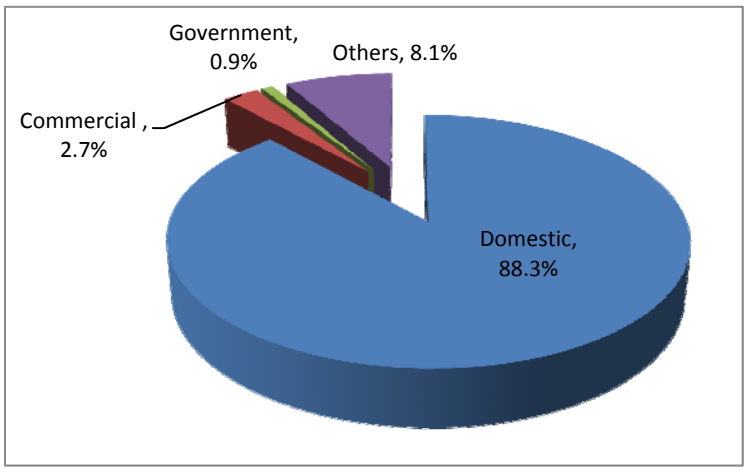
Figure 7: The KSWTP Processes and SCADA System.

Customers/Users:

Treated water is distributed through 15 distribution systems through a total of 35,391 water connections to consumers for domestic, commercial, government and other uses. The total water consumption by different users and the respective proportion are shown in Table 1. Hence, the users of water from the KSWTP are identified and this would enable NWS&DB to determine the different water quality required to meet the different uses of the customers.

Table 1. Total water consumption and the respective proportion by different users.

Category	**Consumption (m^3/month)**
Domestic	367,124
Commercial	11,107
Government	3,660
Others	33,818
Total	**415,709**



3. System Assessment

This section of the WSP covers identification of hazards and hazardous events within the system, evaluates the risks, determines and validates the control measures, develops and implements the upgrade and improvement plan to overcome the risk based on prioritization of risks. Selected risks identified within the Catchment, Treatment, Distribution and Consumers for the KSWTP are summarized in Table 2.

Table 2. Selected hazardous events and risks in the KSWTP.

Water supply system	Hazardous event (source of hazard)	Associated hazards (and issues to consider)
Catchment	Seasonal variations	Changes in river water quality
	Extreme droughts	Inadequate supply of water
	Agriculture	Microbial contamination, pesticides, nitrate
	Small scale industry including service stations, slaughter houses, poultry farms, direct sewage discharge and effluent from septic tanks	Chemical and microbial contamination
		Potential loss of source water due to contamination
	Development/land clearance	Run-off with high total solids
Treatment	Power supplies	Interrupted treatment / loss of disinfection
	Treatment failure	Untreated water
	Fluctuation in free Cl concentration	Inadequate treatment
	Inadequate filter media depth	Inadequate particle removal
	Instrumentation failure	Loss of control
	Flooding	Loss or restriction of treatment works
Distribution	Any hazard not controlled / mitigated within treatment	As identified in treatment
	Mains burst	Ingress of contamination
	Excessive leakage	Ingress of contamination
	Inadequate monitoring	Poor water quality
	Pressure fluctuations	Ingress of contamination
	Intermittent supply	Ingress of contamination
	Use of unapproved materials	Contamination of water supply
	Unprotected service reservoir access	Contamination

Table 2. Selected hazardous events and risks in the KSWTP (con't)

Consumers' premise	Unauthorized connections	Contamination by backflow
	Lead pipes	Lead contamination
	Inappropriate storage systems	Contamination

The risk potential of each hazardous events are based on semi-quantitative approach as shown in Table 3. All the risks need to be documented in the WSP and would be subject to regular review.

Table 3. Semi-quantitative risk assessment approach of the hazardous events identified.

		Severity or consequences or impact				
		Insignificant / No impact (1)	Minor compliance impact (2)	Moderate aesthetic impact (3)	Major regulatory impact (4)	Catastrophic public health impact (5)
Likelihood or frequency	Certain : once/day (5)	5	10	15	20	25
	Likely : once/week (4)	4	8	12	16	20
	Moderate : once/ month (3)	3	6	9	12	15
	Unlikely : once/year (2)	2	4	6	8	10
	Rare: once /5 years or more (1)	1	2	3	4	5
	Risk rating	<6 Low	6-10 Medium	10-15 high		>15 very high

4. Operational Monitoring

Two log books are kept to record the water quality data obtained at the laboratory (turbidity and pH recording at 2-hour intervals, color and electrical conductivity on daily basis) and jar test data. In addition, online measurements of raw water pH, turbidity and color are being recorded by the SCADA system.

All above data and plant production data are collected daily by the call centre established at regional support centre - centralised and handed to the Deputy General Manager for his observations and necessary actions. In addition, data are forwarded to the Water Quality Assurance and Inspection Unit for continuous monitoring and investigations if required.

All defects are observed and recorded based on the type of record, data of observation, remedial activities, reported officer's details and supervisor's details. The related defects are recorded in the respective civil, mechanical or electrical log books (Figure 8) and are further categorized as major and minor defects. These will be summarized at the end of each month for reporting.

Online data management system records for all the water treatment plants' operational data including pumps are inspected by the electrical engineer of the KSWTP.

Figure 8. Log books for monitoring and recording on system operation and water quality.

5. Management and Communication

a. Training and Awareness:

Workshop 1 provided the initial WSP training to the Sri Lanka team members, while Workshop 2 of this project provided awareness on the WSP development and importance of WSP, and also training on the use of WSP QA Tool as an assessment and monitoring tool of WSP.

One day training program was conducted by the NWS&DB staff who was trained at the Workshop 2 of this project for the O.I.Cs in Central Province. It was conducted at the NWS&DB conference room at Katugastota on 4th April, 2012. A series of main out-door bond training program will be conducted with financial assistance from the United Nation Children's Fund (UNICEF) for Public Health Institutes (PHIs) in the three districts.

Awareness campaign are also carried out to the general public. School program has been initiated by involving school children in development and implementation activities of WSPs for their school water supply systems as a learning tool under the awareness program funded by UNICEF. Awareness program was conducted to organizations such as the Ministry of Health, local authorities, community based organizations.

b. Research and Development (R&D)

R&D has been on-going and supported through various funding sources at different local research institutions. This include effluent discharge monitoring and improvement on wastewater treatment in selected industries, in-situ treatment technologies for landfill leachate (Figure 9) and sewage discharge from small communities. Hazard identification in the catchment area has also initiated a program on monitoring the health impact from disinfection by-products (trihalomethane) in the KSWTP service area as a collaborative project with the University of Peradeniya, Sri Lanka. In addition, standard mitigation programs for catastrophic epidemical situations, hazard identification and implementation of control actions were developed based on the experiences enhanced from the APN project for the recent incident happened at Thalawakele, Sri Lanka due to dysentery because of rotavirus.

Further research collaborations between local research institutions and the NWS&DB, as well as with the National University of Singapore on water quality improvement and analysis have been identified and are currently under discussion.

Figure 9. Open landfill next to the the Mahaweli River (left) and in-situ landfill leachate treatment which is undertaken by the University of Peradeniya (A research project lead by Dr Mowjood) (right).

c. Quality Assurance

Water quality of the treatment plant is ensured by the O.I.C. and he summarizes and submit all data daily at 0800 hr to the Deputy General Manager. In addition, all online water quality data are monitored and their trends are analyzed for operational needs.

Referring to the standards established in Sri Lanka (SLS 614:part 2) for sampling, all distribution system is checked and covered for residual chlorine (RCl) and coliforms (fecal and total) by the regional chemist for the

Kandy South (KS) region. He works under the Manager (KS) and there are three managers reporting to the Deputy General Manager for the whole central region.

At any failure in maintaining the recommended RCl in the distribution system and at occurrence of biological contamination, the chemist (KS) must inform to the O.I.C of the WTP and the district engineer (there are two District Engineers are under Manager (KS)). They are responsible to rectify the issue and report back to the chemist within 3 days. Manager (KS) monitors the overall progress.

The handbook developed by Dr R. Weerasooriya on Quality Control and Quality Assurance (QC/QA) on Water Quality under the USAID-IFS project will be reviewed for implementation by the NWS&DB to further enhance the water quality assessment for the treatment plants. In addition, inter-laboratory assessment is being considered as part of the quality assurance step in the water quality assessment. Preventive maintenance such as analysis equipment calibration is also carried out periodically, either weekly or monthly, to ensure reliability of the data collected.

NWS&DB has established a Call Center (Figure 10) that operates 24 hours to address customers' complaints. This is important to receive feedbacks from consumers to further improve the water supply services and to provide assurance to the customers that NWS&DB strives to provide good quality water that meets the local potable water standards.

Figure 10. Customers' feedback hotline details posted on signboards and on NWS&DB vehicles.

6. Feedback

Periodic reviews are in place through internal audits which are carried out periodically within the KSWTP operation team and external audits by Expert Panels will be in place half yearly following the implementation of the WSP.

Preliminary findings and challenges in Implementing WSP for the KSWTP:

The main problems identified in ensuring safe water in the KSWTP lies in the:

(1) catchment management , namely (a) open dumping sites near the river banks which leads to long term leachate outfall into the river; (b) effluent discharge from industries that exceeds effluent standards regulatory requirement; (c) direct sewage outfall and effluent from septic tanks from households along the river banks, and

(2) distribution systems, namely (a) aged distribution pipes that have high unaccountable water loss and could be corroded and highly filled with biofilm; and (b) illegal connections.

Hence, involving stakeholders in the Steering Committee from related ministries such as representations from Local Government Authorities, Health Ministry, Environmental police and Central Environmental Agency (CEA) could bring this problem for their follow up actions.

In addition, the WSP Quality Assurance Tool introduced during Workshop 2 could be used as an assessment and reporting tool on the progress on the WSP to higher management, policy and decision makers. This aids in decision making on where resources could be best used to improve the water supply.

4.0 Dissemination plan

Through the collaborators in Sri Lanka, dissemination of the knowledge transferred especially in the WSP development will be through capacity building achieved at local and national level through training of water personnel throughout the country and the young water professionals in tertiary institutions.

University of Peradeniya has incorporated the WSP training into their undergraduate and postgraduate modules. At the undergraduate level, a lecture on Hazard Assessment (Vulnerability and Hazardous) and water quality objectives for the catchment has been incorporated into the module on Environmental Hydrology for undergraduate students specializing in Biosystems Engineering. At the postgraduate level, Master of Science students in the Integrated Water Resources Management (IWRM) programme and Biosystems Engineering programme are receiving training on WSP in the module on Water Quality for Agriculture and Environment.

Training programs are conducted by the NWS&DB staff who was trained at the Workshop 2 of this project for the NWS&DB staff from other provinces.

One interim progress report on the preliminary findings on possible water management strategies for implementation in Sri Lanka has been prepared.

The team has prepared a preliminary WSP for the KSWTP to ensure supply of safe water from source to tap and is currently preparing a joint paper publication on the Water Safety Plan development for the KSWTP - strategic plans and challenges for safe water.

5.0 Conclusions

This project, through two workshops, organized in Singapore and Kandy, Sri Lanka have achieved capability building by transfer of valuable sustainable strategies on water resource management between Singapore and Sri Lanka, as well as the technical knowledge in water treatment technologies and water quality assessment. The workshops have also provided training on the development and implementation of WSP which is viewed as an important risk based assessment tool to evaluate and ensure safe water supply from source to tap. The KSWTP, Sri Lanka was used in a pilot-case study to establish the approach and strategy for the development and implementation of the WSP. The WSP approach in this case study has identified potential areas to enhance continuous supply of safe water as well as challenges in implementing the WSP. Comprehensive water quality monitoring and quality assurance schemes are currently being developed. This project has raised awareness on the importance of WSP to the higher management level and have brought together the local expert members

and water supply authority to work towards sustaining good and safe water supply in Sri Lanka.

6.0 Future Directions

It is important that the preliminary WSP for the KSWTP developed in this project is periodically reviewed and updated. The procedures in the WSP are also up-to-date and the staff are aware of the changes. Hence, continuous effort are required to maintain the WSP. The WSP for the KSWTP is a pilot case study in Sri Lanka and NWS&DB will be reviewing the strategies from this case study to be implemented to other treatment plants in the country.

Further collaborative and integrated effort between NWS&DB and the institutions for continuous improvement on WSP and risk control and monitoring are on-going. The technical strength and expertise from various organizations and institutions are being explored such as expert advisory, and analytical expertise and resources to have more comprehensive water safety management and assurance.

The Singapore and Sri Lanka teams have identified areas on information sharing and further technical collaborations in catchment management, water treatment technologies and quality assessment.

Further project collaborations are:

1. Spatial-temporal analysis of nitrate contamination in Sri Lankan wells due to agricultural activities 1984-2012.
Sharing of data which the Singapore team will work on GIS mapping.
S.K. Weragoda, NWS&DB, Sri Lanka; Prof Kawakami, Toyama University, Japan; Han She Lim and Lai Yoke Lee, National University of Singapore, Singapore

2. Assessment and development of DIY filters for suspended solids and nitrate removal from contaminated water source.
This project is part of the Science Mentorship Program under the Ministry of Education, Singapore for Secondary School students to establish Research and Development (R&D) capability.
Mentors: Lai Yoke Lee and Say Leong Ong, National University of Singapore, Singapore
Advisor: S.K. Weragoda, NWS&DB, Sri Lanka

References

Bartram J. , Corrales L., Davison A., Deere D., Drury D., Gordon B., Howard G., Rinehold A and Stevens M. (2009). Water Safety Plan Manual: step-by-step risk management for drinking water suppliers. World Health Organization (WHO) Geneva.

Sri Lanka Standards Institute (1985). Sri Lanka Standards (SLS) 722. Tolerance Limits for Inland Surface Waters used as Raw Water for Public Water Supply. Colombo, Sri Lanka: http://www.slsi.lk/.

World Health Organization (WHO) (2011). User Manual: Water Safety Plan Quality Assurance Tool. World Health Organization (WHO) Geneva.

Appendix 1

Water Safety Plan for Kandy South Water Treatment Plant

WSP Teams and their roles:

Initiating Group:

Roles

- Study WSP Concept through Literature Review and Training
- Initiate the background work for WSP
- Identify a working plan
- Identify members for different working teams

Steering Committee

Roles:

- To provide political support
- To coordinate WSP implementation activities with stake holders

Members:

- Chairman/NWS&DB
- Deputy General Manager/NWS&DB
- Senior Engineer/NWS&DB (Convenor/SC)
- Senior Lecturer/UoP (Consultant)
- Representation from Local Government Authorities
- Representation from Health Ministry
- Representation from Environmental police
- Representation from CEA

Task Force (aka Water Safety Team):

Roles:

- Modify the WSP proposed by the Initiating Group through member's technical expertise and work experience
- Implement the WSP
- Maintain the WSP

Members comprise:

Senior Managers of the utility

- To get Management support
- Changes of working practices
- Ensure sufficient financial support
- Promote water safety as a goal of the organization

Operational staff

- Posses skills to identify hazards, risks and controlled measures
- Have authority to implement the recommendations stemming from the WSP

Basis of Members selection:

- Technical expertise and system-specific experience
- Availability
- Organizational authority

- Educational level (person should be able to understand WSP related issues and communicate, effectively)
- Attitudes (appreciate WQ need and value consumers)

Expert Panel

- Roles:
- Provide technical support
- Prepare a short documentation
- Explaining WSP methodology
- How to implement
- What to be achieved
- Develop computer based training programmes
- Arrange training programmes on request
- Perform as an “Independent Monitoring Group” until the government established a “Regulating Authority”

Appendix 2:

Workshop 1:
National University of Singapore
September 19-22, 2011

Date	Program
19 Sept 2011 Monday Venue: Auditorium, Block EA, Faculty of Engineering, 9 Engineering Drive 1, NUS, Singapore 117576	Information sharing and learning platform 0830 – 0900 Registration 0900 – 0910 Opening 0910 – 0935 Sustainable Water Management: Singapore Strategies – Prof Ong Say Leong, NUS 0935 – 1000 Technology for Water Reclamation and Reuse – Assoc Prof Ng How Yong, NUS 1000 – 1025 Possible Risks Involved in Conventional Water Treatment Process and Distribution Systems in Sri Lanka and Appropriate Alternative Solutions: A Case Study – Dr J. Manatunge, University of Moratuwa 1025 – 1045 Tea break 1045 - 1110 Alternative Disinfection for Drinking Water Treatment– Assoc Prof Hu Jiang Yong, NUS 1110 – 1135 Water Quantity/Quality Field Sampling Techniques – Asst Prof Lim Han She, NUS 1135 – 1200 Strengthening our Management of Drinking Water Quality and Safety – Mr Jonathan Goh, Analytical Laboratories (S) Pte Ltd 1200 – 1225 Water Quality Monitoring for the Supply of Drinking Water at NWS&DB – Dr C.S. Kalpage, University of Peradeniya 1225 – 1250 Membrane Processes in Water Treatment - Mr S. Sathananthan, Ngee Ann Polytechnic 1250 – 1400 Lunch 1400 – 1425 Singapore's Piped Drinking Water Quality Standards and Regulations - Dr. Pranav S. Joshi, National Environment Agency 1425 – 1450 Water Safety Management at the Waterworks – Mr Lim Mong Hoo, Public Utilities Board 1450 – 1515 Water Supply Management in Sri Lanka – Mr N.E.M.S.B. Ekanayake, National Water Supply and Drainage Board 1515 – 1535 Tea break

	1535 – 1600 Treatment Process and Need of WSP for KS WTP, Sri Lanka – Dr S.K. Weragoda, National Water Supply and Drainage Board 1600 – 1625 Challenges to Water Treatment in Sri Lanka – Dr G.B.B. Herath, University of Peradeniya 1625 – 1650 Pollution of Waters and Soils of Sri Lanka from Trace Elements – Dr M. Vithanage, Institute of Fundamental Studies 1650 – 1715 Importance of Proper Agricultural Inputs to WSP – Dr M.I.M Mowjood, University of Peradeniya 1715 – 1730 Asia Pacific – Water Safety Plan Network – Mr Woo Chee Hoe, Public Utilities Board
20 Sept 2011 Tuesday Venue: EA-01-06, Faculty of Engineering, 9 Engineering Drive 1, NUS, Singapore 117576	Round table discussion 0900 – 1200 Discussion and Summary on Day 1's topics 1200 – 1300 Lunch 1300 – 1800 Pilot study – Development of safe water management plan for Kandy South Water Treatment plant
21 Sept 2011 Wednesday Venue: Workshop 2, Level 2, Water Science and Technology Laboratory, Centre for Water Research, NUS	Laboratory demonstration and hands-on water quality analysis 0930 – 1700 Giardia and Cryptosporidium detection – Madam Tan Xiaolan, NUS Demonstration on LCMS for detection of emerging contaminants in water – Ms Chu Xiaona, NUS 1800 – 2000 Discussion – Planning for Workshop 2 Dinner Venue: Sun Bistro Restaurant, NUS Staff Club
22 Sept 2011 Thursday Venue: Workshop 2, Level 2, Water Science and Technology Laboratory, Centre for Water Research, NUS	Laboratory demonstration and hands-on water quality analysis (con't) and Site Visits 0900 – 1200 Continue on Laboratory hands-on water quality analysis 1200 – 1250 Lunch break 1250 Gather outside EA Auditorium 1300 – 1330 Depart to Chestnut Ave Water Works (CAWW) 1330 – 1445 Visit to CAWW 1445 – 1530 Depart to NEWater Visitors' Centre 1530 – 1630 Visit to NVC *Coach will return to Victoria Hotel and NUS End of Workshop 1

Participants from Singapore

No	Name	Title	Gender	Organization	Designation	E-mail	Tel	Fax	Roles in APN Project	Roles in 1st Workshop
1	NG How Yong	Dr	M	Centre for Water Research, NUS	Director; Associate Professor	ceenghy@nus.edu.sg	65 65164777		Overall project leader and coordinator, Specialist in water reclamation and reuse; and renewable energy	Overall in-charge for Workshop 1 organization. Presentation on water reclamation and reuse technology
2	LEE Lai Yoke	Dr	F	Tropical Marine Science Institute, NUS	Research Fellow	tmslly@nus.edu.sg	65 65163003	65 67761455	Assist in overall project coordination and administration; workshop organization; Water management and water quality analysis, training on water safety plan development	Organize Workshop 1 ; Training on Water Safety Plan Development
3	HU Jiang Yong	Dr	F	Department of Civil and Environmental Engineering, NUS; Environmental Engineering Society of Singapore	Associate Professor; President	ceehujy@nus.edu.sg	65 65164777		Provide expertise in water treatment technologies and emerging contaminants detection	Presentation on water treatment technologies and emerging contaminants control

4	LIM Han She	Dr	F	Department of Geography, NUS	Assistant Professor	geolhs@nus.edu.sg	65 65163858		Provide scientific knowledge on water resource system and hands-on training on source water sampling and water quality analysis.	Presentation on watershed runoff monitoring and water sampling methods
5	ONG Say Leong	Dr	M	Department of Civil and Environmental Engineering, NUS; Environmental Engineering Society of Singapore	Professor	ceeongsl@nus.edu.sg	65 65162890		Sharing of experience and technical expertise in water supply, treatment and water reclamation.	Presentation on water management; sharing of experience in water management and safety.
6	TAN Xiaolan	Ms	F	Department of Civil and Environmental Engineering, NUS	Laboratory Officer	ceetanxl@nus.edu.sg	65 66011566		-	Lab training - Hands on training on Cryptosporidium and Giardia Detection
7	CHU Xiaona	Ms	F	Department of Civil and Environmental Engineering	Research Fellow	ceecx@nus.edu.sg	65 65161216		-	Laboratory training - demonstration on emerging contaminants detection.
8	Olivier Patrick LEFEBVRE	Dr	M	Department of Civil and Environmental Engineering	Research Fellow	ceelop@nus.edu.sg	65 65165265		Assist in coordinating reports for the project	Assist in coordinating and planning for Workshop 1

Participants from Sri Lanka

No	Name	Title	Gender	Organization	Designation	E-mail	Tel	Fax	Roles in APN Project	Roles in 1st Workshop
1	N.E.M.S.B. Ekanayake	Mr	M	Natioanl Water Supply and Drainage Board	Assistant General Manager (Central Province Sri Lanka	agmrscc@slt.net.lk	+94 81 2387149; +94 77 2017800	+94 081-2388027	Assisting the Team leader, Mr Mr Attanayake, for Sri Lankan team and assist in implemetation WSP for KS WTP, Sri Lanka	Presentation on Water Supply Management in Sri Lanka
2	S.K. Weragoda	Dr	M	Natioanl Water Supply and Drainage Board	Plant Engineer (Kandy South Water Treatment Plant)	skwera@yahoo.com	+94 81 2385725, +94 77 3648451	+94 81 2388027	Coordinator for Sri Lankan team and responsible for developing WSP fro KS WTP	Presentation on Treatment Process and need of WSP for KS WTP
3	J. Manatunge	Dr	M	Faculty of Engineering, University of Moratuwa	Senior Lecturer	manatunge@civil.mrt.ac.lk	+94 11 2882902, +94 71 8045546		Water Treatment-Inputs from treatment technology	Presentation on Different Water Treatment Technology used in Sri Lanka
4	G.B.B. Herath	Dr	M	Faculty of Engineering, University of Peradeniya	Senior Lecturer	gemunuh@pdn.ac.lk; bhumindra@yahoo.com	+94-81-2393572, +94 77 3689838	+94-81-2388158	Water Pollution-Inputs on pollution prevention/mitigation and catchment management	Presentation on Challenges in WTP, Sri Lanka

5	M.I.M Mowjood	Dr	M	Faculty of Agriculture, University of Peradeniya	Senior Lecturer	mmowjood@pdn.ac.lk	+94 81 2395469, +94 77 7356342	+94 81 2395454	Agricultural importance -Inputs on riparian vegetation/management/pollution prevention	Presentation on importance of proper agricultal inputs to WSP
6	C.S Kalpage	Dr	M	Department of Chemical and Processing Engineering, Faculty of Engineering, University of Peradeniya	Senior Lecturer	csk@pdn.ac.lk	+94 81 2393694		Laboratory analysis- Use of laboratory analysis in developing WSP	Presentation on needs of lab analysis for WSP
7	M. Vithanage	Dr	F	Institute of Fundamental Studies	Senior Scientist	meththikavithanage@gmail.com	+94 812 232 002	+94 812 232 131	Ground water specialist- Effects from ground water/pollution/management	Presentation on groun water quality/ pollution and management in catchment

Workshop 2, 22- -2 4 February 2012, Kandy, Sri Lanka

Detailed Program

Date	Time	Activity
Feb-22	**Day 01 of APN Workshop 02 in Sri Lanka**	
Wednesday	**Morning Session**	Demostration on application of Wetland Systems for Pollution Control in Central Region of Sri Lanka *Organized By: Dr MIM Mowjood, Senior Lecturer, University of Peradeniya*
		Water Treatment Plant Visit to Kandy South Water Treatment Plant, Gampola Road, Peradeniya *Organized By: Dr SK Weragoda, Senior Engineer, National Water Supply and Drainage Board*
	Afternoon Session	Review of Water Safety Plan Development and Future actions at Board Room, Faculty of Agriculture, University of Peradeniya *Organized By: Dr CS Kalpage, Senior Lecturer,Unniversity of Peradeniya*
Feb-22	**Detailed Program**	
	Morning Session	
	0830 hr	Field visit to Wetland system in Digana (Meeting point at Earl's Regency Hotel Entrance, near Thennakumbura Bridge)
	0900 hr	Reach to site and discussion with the Management of Milco factory on performances
	0915 hr	Visit the factory effluent discharge processes and wetland unit
	1000 hr	Leave Milco Factory (Tea on the way)
	1115 hr	Visit Kandy South Water Treatment Plant (KS WTP), Gampola Road, Peradeniya
	1120 hr	Demostration of KS WTP Operation and SCADA function, By Mr JMC Karunarathne, Plant Engineer, KS WTP
	1140 hr	Visit to plant site for operational procedures, Demonstration by Mr RGSP Pushpakumara, Officer In Charge, KS WTP
	1315 hr	Leave Kandy South WTP
	1330 hr	Lunch (Peradeniya)
	Afternoon Session	
	1430 hr	Progress meeting and discussion at Board Room, Faculty of Agriculture, University of Peradeniya Chaired By: Dr Gemunu Herath and Dr MIM Mowjood, Senior Lecturer, University of Peradeniya
	1435 hr	Welcome address by Mr Ekanayake, Assistant General Manager (Central), National Water Supply and Drainage Board
	1440 hr	Brief on Development of Module 01 of Water Safety Plan (WSP): Dr CS Kalpage, Senior Lecturer, University of Peradeniya

	1500 hr	Brief on Development of Module 02 of WSP: Dr SK Weragoda, Senior Engineer, National Water Supply and Drainage Board
	1520 hr	Brief on Development of Module 03 of WSP: Dr M Vithanage, Senior Researcher, Institute of Fundamental Studies
	1540hr	Tea
	1600 hr	Discussion on the development and implementation of the WSP
	1630 hr	Discussion on the possible future collaborative studies
	1650 hr	Concluding remarks and end of the Day 01- Workshop 02
	1700 hr	End of the Day 01 of APN Workshop 02
Feb-23	**Day 02 of APN Workshop 02 in Sri Lanka at Seminar Room, Greater Kandy WTP**	
Thursday	**Inauguration Session**	Introduction to the Project
	Morning Session	*Co-Chaired by Associate Prof Jiang Yong HU, National University of Singapore and Dr CS Kalpage, University of Peradeniya*
	Afternoon Session	*Co-Chaired by Associate Prof How Yong NG, National University of Singapore and Mr MAMSL Attanayake, National Water Supply and Drainage Board*
Feb-23	**Detailed Program**	
	Inauguration Session	
	0800 hr	Registration of participants for the 2nd Workshop at NWS&DB Training Centre, Katugastota
	0820 hr	Inaugural Session
	0820 hr	National Anthem
	0825 hr	Welcome address and Objective of APN Workshop 02 by Mr MAMSL Attanayake, Deputy General Management (Central), National Water Supply and Drainage Board, Kandy
	0835 hr	Briefing of the project By Associate Prof NG, APN funded Project Leader, National University of Singapore (NUS), Singapore
	0845 hr	Summary of the Workshop 01 held in Singapore by Mr. NEMSB Ekanayake, Assistant General Manager, National Water Supply and Drainage Board
	0850 hr	Special Speech: Biostability and its Application in Drinking Water Quality Management by Associate Professor Jiang Yong HU, National University of Singapore
	0910 hr	Conference Photo
	0920 hr	Tea Break
	Morning Session **Co-Chaired by Associate Prof Jiang Yong HU, National University of Singapore and Dr CS Kalpage, University of Peradeniya**	

0940 hr	WSP and its Application in Sri Lanka; Progress and challenges, Dr Gemini Herath, Faculty of Engineering, University of Peradeniya
1000 hr	Drinking water supply challenges in Sri Lanka, Mr Peries, Deputy General Manager (North Central), National Water Supply and Drainage Board, Anuradhapura
1020 hr	Catchment Protection in WSP, Sri Lanka perspectives, By Dr MIM Mowjood, Faculty of Agriculture, University of Peradeniya
1040 hr	Bioretention Systems in Urban Storm Water Management by Dr Lai Yoke LEE, National University of Singapore
1100 hr	Chemical pollution risk to water resources in Sri Lanka, Dr Meththika Vithanage, Institute of Fundamental Studies, Kandy
1120 hr	Hybrid alum coagulation-membrane filtration system for virus removal in water treatment process by Ms Huiling GUO, National University of Singapore
1140 hr	The Use of Membrane Technology for Wastewater Treatment and Reclamation by Associate Professor How Yong NG, National University of Singapore
1200 hr	Open Discussion
1230 hr	Lunch
Afternoon Session **Co-Chaired by Associate Prof How Yong NG, National University of Singapore and Mr MAMSL Attanayake, National Water Supply and Drainage Board**	
1330 hr	WSP Quality Assurance Tool: An Introduction, Orientation & Consideration for Application of the WSP QA Tool By Dr Lai Yoke Lee, National University of Singapore
1420 hr	Water testing capacity, Instrumentation and Monitoring and Laboratory Accreditation for WSP: National Water Supply and Drainage Board by Ms M Makehelwala, Chemist, National Water Supply and Drainage Board
1440 hr	Tea Break
1500 hr	Fieldwork Investigation of Environmental Impacts of Community-based Wastewater Treatment Systems by Assistant Professor Han She LIM, National University of Singapore
1520 hr	Consumer Perceptions in Water Quality, By Mr. LI Wickramasinghe, Senior Sociologist, National Water Supply and Drainage Board
1540 hr	Open Discussion
1630 hr	Concluding Remarks, Mr. NEMSB Ekanayake, National Water Supply and Drainage Board
1640 hr	Guest Speech by Mr Karunasena Hettiarachchi, Chairman, National Water Supply and Drainage Board, Sri Lanka
1650 hr	Certificate Awarding for participants
1705 hr	Vote of Thank by Dr GBB Herath, University of Peradeniya
1715 hr	End of the Day Session
1830 hr	Workshop Dinner at Oak Ray Hotel, Deweni Rajasinghe Mawatha, Getambe, Kandy
2030 hr	End of the Day 02- Workshop 02

Feb-24	**Day 03 of APN Workshop 02 in Sri Lanka**	
Friday	**Morning Session**	Field visit to Kandy South WTP catchment area *Organized By: Dr MIM Mowjood, Faculty of Agriculture, Unniversity of Peradeniya*
	Afternoon Session	Visit to Institute of Fundamental Studies (IFS) for Singapore Team Visit to Institute of Fundamental Studies (IFS) for Singapore Team *Organized By: Dr M Vithanage, Senior Researcher, Institue of Fundemental Studies*
	Detailed Program	
	Morning Session	
	0800 hr	Gather at PGIA, Peradeniya
	0830 hr	Field visit to Kandy South WTP catchment area, Pussella, Gampola *Organized By: Dr MIM Mowjood, Senior Lecturer, Unniversity of Peradeniya* Field sampling demostration by National Water Supply and Drainage Board, Kandy
	1300 hr	Lunch on the way to Kandy
	Afternoon Session	
	1400 hr	Visit to Institute of Fundamental Studies (IFS) for Singapore Team *Organized By: Dr M Vithanage, Senior Researcher, Institue of Fundemental Studies*
	1530 hr	Tea
	1600 hr	End of the Day 03- Workshop 02

APN-FUNDING UNDER THE CAPaBLE PROGRAMME

Project Reference: CBA2011-14NSY-Ng

Project Title: Water Safety from Source to Tap – Strategies and Implementations

Workshop 2: Kandy, 22-24 Feb 2012

Participants from
Singapore

Name	Title	Gender	Organization	Designation	E-mail	Tel	Fax	Roles in APN Project	Roles in Workshop 2
NG How Yong	Dr	M	Centre for Water Research, NUS	Director; Associate Professor	ceenghy@nus.edu.sg	65 65164777		Overall project leader and coordinator, Specialist in water reclamation and reuse; and renewable energy	Sharing on the use of membrane technology for wastewater treatment and reclamation as sustainable water resource and also to safeguard the quality of receiving water.
LEE Lai Yoke	Dr	F	Tropical Marine Science Institute, NUS	Research Fellow	tmslly@nus.edu.sg	65 65163003	65 67761455	Assist in overall project coordination and administration; workshop organization; Water management and water quality analysis, training on water safety plan development	Sharing on bioretention system as an insitu treatment for stormwater runoff in catchment management, and discussion on water safety plan evaluation tool

HU Jiang Yong	Dr	F	Department of Civil and Environmental Engineering, NUS; Environmental Engineering Society of Singapore	Associate Professor; President	ceehujy@nus.edu.sg	65 65164777		Provide expertise in water treatment technologies and emerging contaminants detection	Sharing on biostability and its application in drinking water quality management
LIM Han She	Dr	F	Department of Geography, NUS	Assistant Professor	geolhs@nus.edu.sg	65 65163858		Provide scientific knowledge on water resource system and hands-on training on source water sampling and water quality analysis.	Sharing of fieldwork investigation of environmental impacts of community-based wastewater treatment systems.
GUO Huiling	Ms	F	Department of Civil and Environmental Engineering, NUS; Environmental Engineering Society of Singapore	Research Engineer	ceegh@nus.edu.sg	65 65162182		Sharing of experience and technical expertise in water supply, treatment and water reclamation.	Sharing on technical experience on water treatment process: Hybrid alum coagulation-membrane filtration system for virus removal in water treatment process

Name	Title	Gender	Organization	Designation	E-mail	Tel	Fax	Roles in APN Project	Roles in Workshop 2
M.A.M.S.L Attanayake	Mr	M	National Water Supply and Drainage Board	Deputy General Manager (Central Province Sri Lanka	dgmrsccs@sltnet.lk	+94 81 2387149; +94 77 7753552	+94 081-2388027	Team leader for Sri Lankan team and assist in implementation WSP for KS WTP, Sri Lanka	Sharing knowledge on WSP implementation in Sri Lanka

N.E.M.S.B. Ekanayake	Mr	M	National Water Supply and Drainage Board	Assistant General Manager (Central Province Sri Lanka	agmrscc@slt.net.lk	+94 81 2387149; +94 77 2017800	+94 081-2388027	Assisting the Team leader, Mr Mr Attanayake, for Sri Lankan team and assist in implementation WSP for KS WTP, Sri Lanka	Evaluation of Workshop 02 for its outcomes for improvements and implementation of WSP in KS WSS
S.K. Weragoda	Dr	M	National Water Supply and Drainage Board	Senior Engineer (Process Development)	skwera@yahoo.com	+94 81 2385725, +94 77 3648451	+94 81 2388027	Coordinator for Sri Lankan team and responsible for developing WSP fro KS WTP	Sharing experiences and progress of Preparing WSP for KS WSS
J. Manatunge	Dr	M	Faculty of Engineering, University of Moratuwa	Senior Lecturer	manatunge@civil.mrt.ac.lk	+94 11 2882902, +94 71 8045546		Water Treatment-Inputs from treatment technology	Implementation of WSP for KS WSS
G.B.B. Herath	Dr	M	Faculty of Engineering, University of Peradeniya	Senior Lecturer	gemunuh@pdn.ac.lk; bhumindra@yahoo.com	+94-81-2393572, +94 77 3689838	+94-81-2388158	Water Pollution-Inputs on pollution prevention/mitigation and catchment management	Sharing experiences on WSP and its Application in Sri Lanka; Progress and challenges in other WSS
M.I.M Mowjood	Dr	M	Faculty of Agriculture, University of Peradeniya	Senior Lecturer	mmowjood@pdn.ac.lk	+94 81 2395469, +94 77 7356342	+94 81 2395454	Agricultural importance -Inputs on riparian vegetation/management/pollution prevention	Sharing experiences on Catchment Protection in WSP, Sri Lanka perspectives and organizing field visits

C.S Kalpage	Dr	M	Department of Chemical and Processing Engineering, Faculty of Engineering, University of Peradeniya	Senior Lecturer	csk@pdn.ac.lk	+94 81 2393694		Laboratory analysis- Use of laboratory analysis in developing WSP	Sharing experiences on Development of Module 01 of Water Safety Plan for KS WSS
M. Vithanage	Dr	F	Institute of Fundamental Studies	Senior Scientist	meththikavithanage@gmail.com	+94 812 232 002	+94 812 232 131	Ground water specialist- Effects from ground water/pollution/management	Sharing experience on chemical pollution risk to water resources in Sri Lanka

Name	Title	Gender	Organization	Designation	E-mail	Tel	Fax	Roles in APN Project	Roles in Workshop 2
R.Weerasooriya	Dr	M	Faculty of Agriculture	Senior Lecturer	rweerasooriya@hotmail.com	+94 72 7172525		Expert on laboratory analysis and instrumentations	Sharing experiences on Instrumentation, Monitoring and Laboratory Accreditation
M. Makehelwala	Mrs	F	National Water Supply and Drainage Board	Chemist (Process Development Unit)	madhu23w@yahoo.com	+94 72 7172521		Laboratory testing demonstration-Use of GCMS and TOC	Sharing experiences on Water testing capacity for WSP: National Water Supply and Drainage Board

P.G.L.A Samaranayake	Mrs	F	National Water Supply and Drainage Board	Chemist (Kandy North Region)	anupamacpl@yahoo.com	+94 72 2921963		NWS&DB Laboratory testing practices	Compeer of the Day 02 Program of Workshop 02 and implementation of WSS for other major WSSs in Kandy, Sri Lanka
J.M.C. Karunarathne	Mr	M	National Water Supply and Drainage Board	Plant Engineer (Kandy South Water Treatment Plant)	jmckaru@gmail.com	+94 77 3887707		Implementation of WSP at KS WTP	Demonstration and sharing experiences in KS WSS operation
R.G.S.P. Pushapakumara	Mr	M	National Water Supply and Drainage Board	Officer In Charge (Kandy South Water Treatment Plant)	pkumara75@yahoo.com	+94 77 3887704		Implementation of WSP at KS WTP	Implementation of WSP for KS WSS and field demonstration on plant operation
H.K. Sunil Santha	Mr	M	National Water Supply and Drainage Board	Senior Sociologist		+94 77 6260451		Study of KS WTP catchment for land use pattern and pollution threats	Implementation of WSP for rural WSS in Central Region
K.M.N.S Jinadasa	Dr	M	Faculty of Engineering, University of Peradeniya	Senior Lecturer	shamnj@hotmail.com	+94 77 2519952		Water and wastewater treatment expert	Program organizer and coordinator
D.M.P. Dissanayake	Mr	M	National Water Supply and Drainage Board	Manager (Production)	dmpadmasiri@yahoo.co.in	+94 77 2016634		Implementation of WSP at KS distribution system	Implementation of WSP for KS WSS
N.I. Wickramasinghe	Mr	M	National Water Supply and Drainage Board	Senior Sociologist	niwicky123@gmail.com	+94 71 2442069		Evaluate the pre and post consumer impacts from implementation of WSP in KS WSS	Sharing experiences on Consumer Perceptions in Water Quality

C. Narasinghe	Mrs	F	National Water Supply and Drainage Board	Senior Engineer (Planning and Design)	chandrikanarasinghe@yahoo.com	+94 71 4426923		Improving water treatment facility at KS WTP	Sharing design experiences and improvements in WSSs
G.P.M.R.Weerakoon	Mrs	F	Faculty of Engineering, University of Peradeniya	Lecturer				Lectures on development of WSP as a management technique in water treatment facility	Sharing experiences on Wetland application and pollution mitigation
LLA Peris	Mr	M	National Water Supply and Drainage Board	Deputy General Manager (NC)	wbdgmnc@waterboard.lk	+94 77 7585400		Application of WSP in North Central region of Sri Lanka	Sharing experiences on Drinking water supply challenges in Sri Lanka
J. Gunasekara	Mrs	F	National Water Supply and Drainage Board	Chemist (NC)	jjayanig@yahoo.com	+94 77 7585401		Application of WSP in North Central region of Sri Lanka	Sharing experiences on water treatment issues in Mahaweli River water fed area in dry zone of Sri Lanka

Funding sources outside the APN

A list of agencies, institutions, organisations (governmental, inter-governmental and/or non-governmental), that provided any in-kind support and co-funding for the project and the amount(s) awarded. If possible, please provide an estimate amount.

List of organizations that provided in-kind support to this project

Organization	**Country**	**Government/Inter-government/Non-government**	**Amount (USD)**
National University of Singapore	Singapore	Non-government	986,531.37
Water Supply and Drainage Board	Sri Lanka	Government	105,777.39
Total			**1,092,308.76**

List of Young Scientists

Name: Mr N.I. Wickramasinghe
Designation and organization: Sociologist, National Water Supply and Drainage Board.
Involvement in the project : Organizing field visit at WS2 and social input to the development of WSP.
Contact details: niwicky123@gmail.com

"Application of water safety plan is very much timely important topic to conduct a training program through workshops. As Sri Lanka does not have enough practical experiences on applying the concept of WSP, this forum provided a great opportunity for Sri Lankan members to make clear the issues arise when development and application levels of WSPs. Understanding on hazard identification in distribution system and at household level provides a solid basis for a sociologist to evaluate the consumer impacts on the WSP. "

Name: Dr Olivier Lefebvre
Designation and Organization: Research Fellow; National University of Singapore
Involvement in the project: Assist in coordinating and planning for Workshop 1
Contact details: ceelop@nus.edu.sg

"My participation at the APN Workshop 1 on Water Safety from Source to Tap - Strategies and Implementations was as a rapporteur and as such was invited to attend the meeting and to report

on it. This workshop was very useful in terms of gaining a clear understanding of the problematic of water safety in developing countries. The first day of the workshop consisted of oral presentations that clearly highlighted the needs of developing countries for proper tools to assess their problems and manage water safety issues. The second day was more practical and consisted of a round table about risk assessments based on case studies. I particularly appreciated the networking opportunities that were presented to me thank to this workshop".

Name: Guo Huiling
Designation and Organization: Research Engineer, National University of Singapore
Involvement in the project: Sharing on technical experience on water treatment process: Hybrid alum coagulation-membrane filtration system for virus removal in water treatment process
Contact details: ceegh@nus.edu.sg

"I participated and presented in the APN Workshop in Kandy, Sri Lanka from 22 – 24 Mar 2012. As an individual who has only engaged in water related laboratory research for the past few years, participation in this workshop provided another dimension of knowledge, precepts pertaining to the birth of a water safety plan for a less developed country. Having been accustomed to the already formulated regulations in Singapore, participation in this workshop enabled me to understand the importance of catchment management and the requirements and factors associated in formulating a water safety plan. The presentations at the workshop provided much information on the current status on the risks posed to water resources in the Kandy area arising from uncontrolled discharge of pollutants from residents and industries along Mahaweli river. Indeed public awareness on the importance of protecting water resources is crucial. Current challenges faced in the implementation of a water safety plan and also the limitations on water parameters detection and laboratory accreditation were also highlighted. Discussion with the locals from University of Peradeniya, the National water supply and drainage board, and site visits to the water treatment plants and the Gampola dumping site painted a clearer picture on the existing situation pertaining to Kandy's water resources. Participation in this workshop has added a new dimension to my understanding of proper catchment management to protect local water resources and the efforts required in putting together a water safety plan for the well-being of a community".

Glossary of Terms

CEA	Central Environmental Agency
Cl	Chlorine
EA-	Engineer Assistant
IWRM	Integrated Water Resources Management
KS	Kandy South
KSWTP	Kandy South Water Treatment Plant
NUS	National University of Singapore
NWS&DB	National Water Supply and Drainage Board
O.I.C	Officer in-charge
PHIs	Public Health Institutes
PLCs	Programmable Logistic Controls
PT	Plant Technician
QA	Quality assurance
QC	Quality control
RCl	Residual chlorine
SCADA	Supervisory Control and Data Acquisition
UNICEF	United Nation Children's Fund
WHO	World Health Organization
WSP	Water Safety Plan