**GUIDELINES ON WATER SAFETY INVESTMENT PLAN (WSIP) FOR APPLICATION IN IMPLEMENTATION OF WATER SAFETY PLAN**

**PHASE 3 IN VIETNAM**

***Prepared by Nguyen Lanh,***

***National Consultant in WSP***

***Ton Tuan Nghia,***

***WHO Technical Officer in Environmental Health***

***Vietnam***

**HANOI, 11 - 2013**

***Acknowledgments***

*Funding for this work was provided by the World Health Organization.*

*The author would also like to thank Mr. Graydon of Atkin Ltd. for his initial background for the preparation of this work.*

Contents

[Abbreviation 1](#_Toc372037274)

[I. Introduction 2](#_Toc372037275)

[II. Overview of WSP and the relationship with WSIP 4](#_Toc372037276)

[II.1 Traditional methods of assessing water quality 4](#_Toc372037277)

[II.2 The Water Safety Plan and Investment Plan 5](#_Toc372037278)

[III. Water Safety Investment Plan 9](#_Toc372037279)

[III.1 Principle of Analysis 9](#_Toc372037280)

[III.2 Methodology of WSIP 12](#_Toc372037281)

[III.2.1 Hazard Identification and Risks Assessment 12](#_Toc372037282)

[III.2.2 Cost estimation for a control measure 13](#_Toc372037283)

[III.2.3 Impact on Risk of a Control Measure 14](#_Toc372037284)

[III.2.4 Priotization of control measures 15](#_Toc372037285)

[III.2.5 Sources of Funding 17](#_Toc372037286)

[III.2.6 Costed Programme of Measures 18](#_Toc372037287)

[III.3 Using WSIP Tool for Cost - Benefit Analysis 20](#_Toc372037288)

[III.3.1 Framework of Analysis 20](#_Toc372037289)

[III.3.2 Tool design 22](#_Toc372037290)

[III.3.3 Sample analysis 25](#_Toc372037291)

[IV. Conclusion 28](#_Toc372037292)

[REFERENCES 29](#_Toc372037293)

# Abbreviation

|  |  |
| --- | --- |
| Term | Meaning |
|  |  |
| ADB | Asian Development Bank |
| ATI | Administration of Technical Infrastructure |
| CM | Control Measure(s) |
| JICA | Japan’s Agency for International Development |
| KHAWASSCO | Khanh Hoa Water Supply and Sewrage Company |
| MARD | Ministry of Agriculture and Rural Development |
| MoC | Ministry of Construction |
| MoF | Ministry of Finance |
| MoH | Ministry of Health |
| MPI | Ministry of Planning and Investment |
| PC | People’s Committee |
| USAID | US Agency for International Development |
| VWSSA | Vietnam Water Supply and Sewerage Association |
| WB | World Bank |
| WHO | World Health Organisation |
| WSC | Water Supply Company |
| WSIP | Water Safety Investment Plan |
| WSP | Water Safety Plan |
| WTP | Water Treatment Plant |

**GUIDELINES ON WATER SAFETY PLAN (WSIP) FOR APPLICATION IN IMPLEMENTATION OF WSP PHASE 3 IN VIETNAM**

# I. Introduction

As a developing country, Vietnam faces many challenges in terms of providing water that meets the quality standards for drinking water (QCVN 01:2009/BYT) or at least the acceptable clean water (QCVN 02:2009/BYT). These challenges would be the results of:

* Unplanned development – Informal housing settlements in the resource area and in urban/semi-urban areas make it difficult to control activities in the catchment area and to locate supply mains.
* Poor sanitation – Poor access to required sanitation conditions, especially from the informal housing settlements, which may result in the contamination of the water source and may also lead to the potential cross contamination of water pipes.
* Locality (geographic factors) – Some plants are situated in rural areas and may not have sufficient finance and/or equipment resource availability to measure the appropriate water quality parameters.
* Lack of system knowledge and technical skills – The operators and staff at water treatment plants do not have the proper qualifications and technical training required to run a plant.
* Limited data availability – Many water utilities have only recently developed the culture of data collection and storage for different purposes.
* Socio-economic factors – A considerable percentage of the population are at the low income level and are most likely to use contaminated water sources as they cannot afford to access better quality water sources. Some cannot afford, or do not know how, to conduct treatment within their homes, i.e. disinfection by some suitable method. This population group is at the greatest risk of infectious disease and illness from poor water supply.

Although water service delivery in Vietnam has reached great milestones, the quality of water produced according to drinking water quality standards cannot always be ensured.

Recently, water infrastructure issues have been receiving increased attention by policymakers and legislators. The renewed attention is due to a combination of several factors, such as:

**- Meeting Regulatory Requirements.** In the case of drinking water systems, the most pressing rules are new, either recently issued or pending, as the result of standard-setting by the Administration of Technical Infrastructure - Ministry of Construction (ATI-MOC) to implement the WSP at all WTPs in Vietnam. These rules impose new or stricter requirements on numerous stages of clean water production and supply, among others. These requirements are old in the sense that most water utilities have been trying to address such similar problems to meet the demand of local communities, but they also are new because only recently, specific requirements for WTP to implement WSP are being identified under the Circular No.08/2012/TT-BXD;

**- Financing Infrastructure Repair or Replacement.** A common practice that is happening more frequently today is the need to repair and replace water infrastructure that has been in place for decades and will soon fail. A common statement one can hear in many water utilities today is that, “We stand at the dawn of the replacement era ... replacement needs are large and on the way. There will be a growing conflict between the need to replace worn-out infrastructure and the need to invest in compliance with new regulatory standards”. Over the long term, several WTP would say that, a higher level of investment than is occurring today is required. For many water systems, a key concern is that government’s funding programs, the largest sources of assistance, do not, in the main, support repair and replacement; their focus is upgrades and new construction needed to achieve drinking water standards;

**- Security.** Beyond the traditional infrastructure needs related to regulatory compliance and system repair and expansion, the uncontrolled illegal connections and/or damages due to civil construction activities in almost all urban areas in Vietnam, generated new investment needs for water supply systems. The national costs of addressing water security needs have not been quantified. ..;

For such various reasons, many WSCs may be confusing in process of development of investment plan for implementation of WSP in their company as there seem to be so many objectives for them while the available budget for funding is quite limited. Then, this Guidelines would serve to guide them to proceed with development of an investment plan that can meet most of basic requirements of WSP in a most cost-effective manner.

# II. Overview of WSP and the relationship with WSIP

## II.1 Traditional methods of assessing water quality

Water quality assessments are conducted by the measurement of certain physical, chemical and microbiological constituents at different points in the water supply system, i.e. water source, treatment works, distribution system and point of use. There are always many constituents present in water but only those that occur in concentrations high enough to cause health and aesthetic problems are most important and are measured frequently. During a water quality assessment, tests are usually conducted for features referred to as general indicators that warn of potential problems in water quality. These are: conductivity, faecal coliforms, pH, turbidity and free chlorine, which are indicators of potential problems and should be frequently tested at all points in the water supply system. Free chlorine can be measured only once water has been treated with chlorine based disinfectants.

Various other constituents can also be measured to assess water quality. These constituents are listed in Table 1 and are arranged in order of decreasing priority. The frequency of monitoring is dependent on the size of population served.

*Table 1: Other constituents to be measured at different points in the supply system when assessing water quality*

|  |  |
| --- | --- |
| **Group B** | |
| • Nitrate/nitrite/amonia | *The presence/concentration of these substances should be measured before water is supplied as they may lead to health problems. Frequency of testing is dependent on the source, treatment applied and the population served* |
| • Fluoride |
| • Sulphate |
| • Chloride |
| • Arsenic |
| • Total coliforms |
| **Group C** | |
| • Cadmium | *These substances occur less frequently but may lead to health problems*. |
| • Copper |
| **Group D** | |
| • Manganese | *Substances that are commonly present that cause aesthetic or economic concern only. Should be measured when assessing water quality for the first time or when there is reason to believe that water quality has changed*. |
| • Zinc |
| • Iron |
| • Potassium |
| • Sodium |
| • Magnesium |
| • Calcium |
| • Hardness |

*Constraints of using indicators to predict risks*

Water quality assessments are more focused on the control of the means of measurement rather than ensuring that operational practices are consistent with producing water that meets the requirements of some Total Quality Management Procedure, ISO9000 for example. The elimination of pathogenic micro-organisms in the water supply is given higher priority in water quality control even though several other factors that lead to poor water quality are existent.

The original development of water quality control has placed major emphasis on the control of bacterial diarrhoeal diseases such as cholera, typhoid and shigellosis. Bacteria are agents that cause severe acute disease and are important to consider as they account for a sizeable proportion of cases of diarrhoeal disease in both developed and developing countries. Within developing countries, epidemics of diseases caused by bacterial pathogens remain widespread.

The major disadvantage of using indicators is during the microbiological determination of water quality. The methods used for microbiological determinations are based on detecting organisms (coliform bacteria) which are indicative of the presence of faecal pollution. If evidence of faecal material in the water is detected, it is assumed that pathogens may be present. By the time pathogens can be detected, there is a strong possibility that water containing these pathogens has already been consumed and disease may therefore have been initiated. This approach would therefore limit the potential for preventative action to be taken. Reliance on end product testing is risky because it gives limited warning of water quality deterioration and therefore impedes the implementation of preventative actions.

## II.2 The Water Safety Plan and Investment Plan

Water Safety Plans (WSPs) are a form of water quality assurance through a multi-barrier concept (WHO 2009). The multiple barrier principle implies that actions are required at all stages in the process of producing and distributing water in order to protect water quality. This includes source protection, treatment (when applied) through several different stages, prevention of contamination during distribution (piped or non-piped) and maintenance within households. The role of indicators is seen as primarily being a means of verification of the WSP in meeting water quality objectives rather than as a routine tool for monitoring water quality.

A WSP provides an organised and structured system to minimize the chance of failure through oversight or management lapse. The process provides consistency with which safe water is supplied and provides contingency plans to respond to system failures or unforeseeable hazardous events. Water safety plans can be developed generically for small supplies rather than for individual supplies

A Water Safety Plan includes three key components (WHO 2009):

• **System assessment** – determines whether the drinking water supply chain (up to the point of consumption) as a whole can deliver water of a quality that meets health-based targets.

• Identifying **control measures** in a drinking water system that will collectively control identified risks and ensure that health based targets are met For each control measure identified, an appropriate means of **operational monitoring** should be defined that will ensure that any deviation from the required performance is rapidly detected in a timely manner.

• **Management plans** describing actions taken during normal operation or incident conditions and documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programmes.

The WSP will guide both day to day actions and long term planning. It will identify crucial aspects that collectively ensure the provision of safe water and aid system managers and operators in gaining a better understanding of the water supply system and the risks that need to be managed (WHO 2009). Some of these aspects include:

• regular monitoring and inspections that signal deteriorating water quality (and prompt action)

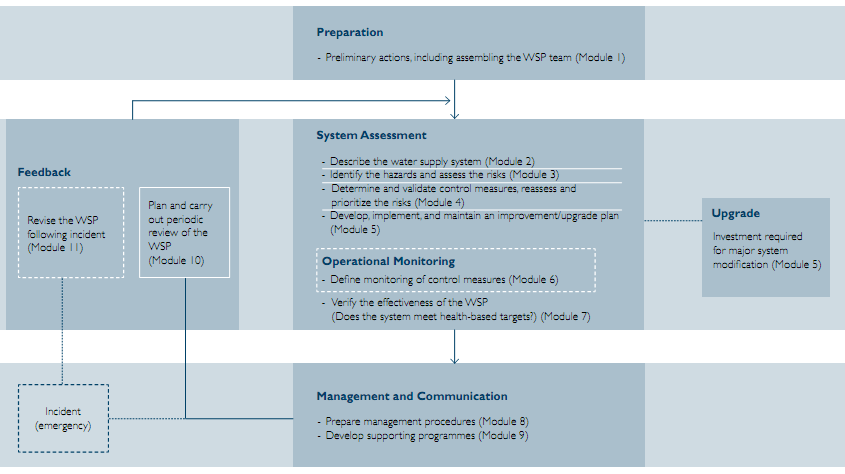
• regular on-going maintenance to reduce the chance of failure by contamination

• guidance for improvement and expenditure

• additional training and capacity building initiatives

• a list of where to get help, who needs to know details of water quality, and how quickly they need to know, etc.

Figure 1 is the flow diagram showing steps to be followed in developing a Water Safety Plan as provided in WHO’s Manual (WHO 2009).



*Fig 1. Structure of modules in a WSP (Adapted from WHO 2009)*

According to the above diagram, one can find that, the Module 5 deals with Investment for major system modification for controlling hazards identified and assessed in previous Modules (Modules 3 and 4). Hence, we can see clearly that the investment is inherent inside the WHO’s WSP, and this investment process for control measures against potential hazards to the system will focus mainly on three steps (modules), from step 3 to step 5, of the WHO’s WSP diagram, where the investment for major system modification is suggested in step 5 (Module 5) which is based on the results of the two previous steps (steps 3 and 4).

In practice of WSP implementation, all WSCs need to perform simultanously two types of work, namely:

1. The immediate actions for upgrading performance of water supply. Such activities may include: improvement of management, source/catchment protection, to clean the system in the water treatment plant, etc.
2. Step-by-step develop and implement investment for upgrading the system to ensure WSP of the Company in long-term. The relating activities may include: improving the distribution network, upgrading the treatment system, additional installment of necessary equipment, etc.

The second type of work usually requires significant investment for improving the quality of water supply of the company, which always need careful cosideration to ensure the benefit against the cost of investment, and that is also the focus of this Guidelines. Figure 2 shows the typical blocks of work for development of WSP in a WSC where the two types of work mentioned above are described by first two small blocks (among three parallel blocks) contributing to the bigger block of “Implementation of WSP”. The third block belongs to management aspect and will be addressed in some other document on management skills for successful implementation of WSP.



*Figure 2: Block scheme of typical work contributing to WSP implementation*

Then, the focus of this Guidelines will concentrate on the “middle second block” above with long term investment for implementation of WSP in WSCs for finding the most effective investment plan with limited available resources.

# III. Water Safety Investment Plan

## III.1 Principle of Analysis

As indicated in the WHO’s WSP diagram, the investment for system modification to address potential hazards in step 5 (module 5) uses analysis and assessment of hazardous events in steps 3 and 4. Then, the analysis for investment plan will concentrate on three basic steps in WHO’s WSP diagram, from step 3 to step 5. If the previous step identifies significant risks to the safety of water and demonstrates that existing controls are not effective or are absent, then an improvement/upgrade plan should be drawn up. Each identified improvement needs an ‘owner’ to take responsibility for implementation and a target implementation date. In general, the assessment may not automatically result in the need for new capital investment. In some instances, all that may be needed is to review, document and formalize the practices that are not working and address any areas where improvements are needed. In other cases, new or improved controls or a major infrastructure change may be needed. Improvement/upgrade plans can include short-, medium- or long-term programmes. Significant resources may be needed and therefore a detailed analysis and careful prioritization should be made in accordance with the system assessment. It may be that improvements need to be prioritized and phased in, and all the things relating to investment for new/upgraded infrastructure of a WTP will be the subject of the investment plan in this work.

Although the starting point of WSIP is practically from step 3 (Hazard identification and risk assessment), but the new procedure of WSIP actually fits in step 4 (Determine and validate control measures, reassess and prioritize the risks), as illustrated in the Figure 3 below. The process is designed to build on the key principles of the WSP approach, particularly in reinforcing the link to impact of the control measures on risk, in order to maximise the cost effectiveness of risk reduction in a financially-constrained environment.

In order to implement WSP in general, and WSIP in particular, the critical issues for all WSC would be the “identification of all feasible control measures” for each potential hazard, as this depends on analytical capacity of each WSP team and also on concrete social conditions at the locality of each WSC. This would be one of the major difficulties in process of implementation of WSP in practice at each WSC.

There is always close relation between a control measure and an identified hazard. In WHO Manual - Chapter 3, there are typical examples of hazards affecting catchment, treatment, distribution network and consumer premises. Correspondingly, the Chapter 4 of that Manual provided the list of suggested control measures for the potential hazards.

In practice, where the control measures under consideration are not individually sufficient to reduce the risk associated with a hazard to an acceptable level, it is envisaged that the measures should be grouped into ‘packages’ of measures, which can be implemented either together or in a phased manner.



*Fig. 3: Overview of investment planning process within WSP 11 step framework (Adapted from Graydon 2010)*

According to the Fig. 3, the analytical approach for development of WSIP will focus on Step 4 among 11 Steps of WHO Guidelines with detailed analysis of ‘Cost and Benefit’ of all potential control measures. The examples given in the WSP literature could be used as a guide to the range of potential control measures which may be considered. Some typical control measures in the Chapter 4 of WHO manual (WHO 2009), that need investment/spending are summarized as below:

*Typical control measures associated with hazards at a catchment*:

* Fences to restrict access to catchments
* Moving stock away from river access at calving / lambing times
* Codes of practice on agricultural chemical use and slurry spreading
* Moving farm operations away from sensitive locations
* Agreements and communication with transport organizations
* Communication and education of catchment stakeholders
* Industrial effluent standards and volume controls
* Raw water storage
* Ability to close intakes (time of travel information)
* River biology – indicator of diffuse or point source contamination
* Covering and protecting springs
* Ability to use good alternative water sources when hazards affect one source
* Continuous monitoring of intake and river
* Site inspections
* Regular internal inspections of wells and boreholes

*Typical control measures associated with hazards at treatment*:

* Validated treatment processes
* Alarmed operating limits
* Stand-by generator
* Automatic shut-down
* Continuous monitoring with alarms
* Trained staff (operator competency)
* Fencing, locked premises, intruder alarms

*Typical control measures associated with hazards at a distribution network*:

* Regular reservoir inspections (external and internal)
* Cover open service reservoirs
* Up-to-date network maps
* Known valve status
* Trained staff (operator competency)
* Hygiene procedures
* Hydrant security
* Non-return valves
* Pressure monitoring and recording
* Protected pipes
* Fencing, locked hatches, intruder alarms for service reservoirs and towers

*Typical control measures associated with hazards at consumer premises*:

* Property inspections
* Consumer education
* Plumbosolvency control
* Non-return valves

From the scheme of analysis shown in Figure 3 with the hints of typical control measures as given in WHO Manual as shown above, the framework of analysis for development of a WSIP can be summarized as follows:

1. Follow step 3 of WSP ‘Hazard Identification and Risk Assessment’: to identify and assess all the potential risks to the system. This is purely the task of WSP implementation, but it creates basis for the next analysis.
2. Follow step 4 of WSP ‘Determine and validate control measures, reassess and prioritize the risks’ but with detailed analysis as shown in Figure 3 for each potential risk identified. To support the analysis in this step, a tool in excel spreadsheet has been developed and will be used for quantitative estimation of cost and benefit of each control measures suggested.
3. Follow step 5 of WSP: development of ‘Improvement Plan’: From the results of cost-benefit analysis for each control measures, a final decision of investment will be made for a ‘package of best control measures’ that can produce the highest impact on the risks with minimal cost.

## III.2 Methodology of WSIP

From the potential risk identified in step 3, all feasible potential control measures should be identified in this step. These measures should be grouped into ‘packages’ of measures where they are not individually sufficient to reduce the risk associated with a hazard to an acceptable level. The procedure of development of WSIP follows steps as given in Figure 3. The methodology of WSIP starting from Step 3 to Step 5 among the 11 Steps of WSP procedure with focusing on Step 4 with the break-downs from the first sub-step 4(i) to the last sub-step 4(v) as illustrated in Figure 3 is presented as follows:

### III.2.1 Hazard Identification and Risks Assessment

This is entirely the content of the Step 3 of WHO WSP procedure and there is nothing new in this Guidelines. However, it needs to mention here as a starting point to proceed with detailed analysis in the next steps. The most important information in this step is the identification of potential hazards and assessment of risks, which seems to be among the most difficult things for the most of WSCs as this depends on analytical capacity of each WSP team and also on concrete social conditions at the locality of each WSC. As instructed in WHO manual the risk is assessed by the known formula:

*Risk = Frequency* x *Impact*

The values of frequency and impact are given in the tabular form as in Table 1 below.

*Table 1: Semi-quantitative risk matrix approach (WHO 2009)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Impact  Frequency | Insignificant or no impact - Rating: 1 | Minor compliance impact - Rating: 2 | Moderate aesthetic impact - Rating: 3 | Major regulatory impact - Rating: 4 | Catastrophic public health impact - Rating: 5 |
| Once a day - Rating: 5 | 5 | 10 | 15 | 20 | 25 |
| Once a week - Rating: 4 | 4 | 8 | 12 | 16 | 20 |
| Once a month - Rating: 3 | 3 | 6 | 9 | 12 | 15 |
| Once a year - Rating: 2 | 2 | 4 | 6 | 8 | 10 |
| Once every 5 year-Rating:1 | 1 | 2 | 3 | 4 | 5 |

The performance of this assessment task will be highly dependent on ability of the WSP team in each WSC, and hence, the judgment may vary from one place to another for the same/similar proposed control measure or a “package of measures”, which implies in the result some source of uncertainty.

### III.2.2 Cost estimation for a control measure

This step is symbolized as sub-step 4 (i) in the Fig.3.

The key objective of this step is to determine the cost of each specific control measures (CMs) for dealing with potential hazards. As such control measure (CM) is not available before, then it is necessary to estimate the additional cost of investment for having and running such CM in the treatment system. Some CMs can also bring about certain benefit, such as saving in labour cost, or reducing the non-revenue water, etc., then, it is necessary to identify all relating costs of any specific CM. The key principles in this step include:

* All significant costs (and potential savings) should be estimated. This should includes costs borne by other stakeholders, not just the WSCs.
* Costs borne by WSCs should be expressed in terms of tariff impact.
* Do not care for that cost estimates may be either high or low at this stage as they can be refined in Step 4 (v).
* The lowest cost ‘package’ of measures should be identified for each hazard based on the results obtained in this step. The individual measures within each package should be taken forward individually (i.e. no longer as a package) to be assessed and prioritised in the subsequent steps.

There are three main categories of cost/saving, which it may be useful to structure the cost estimates around, as outlined in Table 2 below:

*Table 1: Categories of cost/saving*

|  |  |  |
| --- | --- | --- |
| Category | Description | Example |
| Enhancement capital expenditure (capex) | Capital cost of new or improved assets  *Note that this may result in a change in opex and future replacement capex which should also be taken into account.* | New equipment or process at treatment works. |
| Replacement capex | Replacement of existing assets  *Note that this may simply bring forward the date at which the replacement is necessary, and that it may lead to a change in opex, often a reduction.* | Replacement of sand filter media, testing equipment, water mains. |
| Operating expenditure (“opex”) | Costs of operating a system and day to day maintenance. | Additional chlorine purchase.  Additional labour costs for monitoring.  Reduced staff costs for dealing with contamination incidents.  Reduced pumping and treatment costs due to lower non-revenue water levels. |

It should be noted that not all control measures will result in a significant increase in cost, as many envisage changes in operational procedure rather than new assets.

All costs borne by WSCs should be expressed in terms of impact on water tariff so that options can be compared on the same basis, irrespective of whether they are mainly capital expenditure and/or operational expenditure.

An example is presented in Figure 4 below:

Likelihood=3

***Step 3 Step 4 (i)***



*Figure 4: Illustration of cost estimation of a Control Measure*

The tariff impact may be calculated approximately as follows:

Tariff impact (VDN/m3)= (Annual opex change + Annual Debt Repayment)

Total annual billed volume

Where the Cost Estimation should be expressed in term of monetary value over the whole period of repayment, including both grace-loan period and post-grace period loan terms (interest rates and maturity). Computational procedure will be introduced in the following part of ‘Using Excel tool for Cost – benefit analysis’ under the Item III.3 of this Guideline.

*Note:* *in the above example, the hidden default assumption is that the investment for WSP measure does not affect the sales of water, i.e. the same amount of water is produced and consumed. However, in many practical cases, investment project usually accompanied with productivity expansion leading to higher revenue and the above assumption will be no more valid. Then, such situation will be considered in the last part of this Guideline.*

### III.2.3 Impact on Risk of a Control Measure

This step is symbolized as sub-step 4 (ii) in the Fig.3.

The purpose of this step is to assess the risk-reducing impact of the specified control measure, i.e. the ‘Benefit’ of that CM after knowing its ‘Cost’ in the previous step. The impact of control measures on the level of risk is therefore central when considering the selection and prioritisation of these measures.

The risk assessment is carried out as mentioned in Step 3 of WHO Manual, in this case this is re-assessment of the risk upon the application of the specified CM. The purpose of step 4 (ii) is to extend this assessment to have an understanding of the impact of the potential control measure under consideration. Evaluation of the impact of the measures on risk should use the same approach as used for the risk assessment, but with a focus on how this risk score will be changed by each potential control measure under consideration. The difference of risk scores before and after the use of the CM gives us the impact on risk of the CM.

This step is illustrated as by the Figure 5 below:

***Step 3 Step 4 (i) (ii)***

3

*Figure 5: Illustration of impact on risk of a CM*

In should be noted that sometimes a control measure will only benefit a defined proportion of customers whereas others will benefit all customers, there should be an explicit recognition of the proportion of customers benefiting, if it is not already reflected in the risk score mechanism adopted. For example, increased chlorination at a treatment works or source protection may reduce risk across the whole receiving network, whereas mains renewal in one area may only improve quality in the immediate locality. It is envisaged that this would be taken into account in the risk impact calculation.

### III.2.4 Priotization of control measures

This step is symbolized as sub-step 4 (iii) in the Fig.3.

This step of Prioritisation is conducted based on the results of the earlier steps and it is carried out for two reasons:

1. There are usually several potential measures to deal with the same hazard and the WSC needs to select one “best measure” to invest for implementation to deal with the same hazard.
2. Under the shortage of financial resources for investment, it is necessary to prioritise to implement only prioritized control measures in the short to medium term. Under these circumstances only the highest priority measures would be implemented first (in the short to medium term) and that the remaining measures required to mitigate risk to the system, will be put in place over the longer term as resources become available.

It is proposed that control measures should be prioritised on the basis of the following criteria:

* Measures should be prioritised primarily on the basis of their cost-effectiveness, i.e. cost relative to impact on risk, or tariff impact divided by the change in risk score. This will ensure that maximum benefit derived from the budget available while ensuring to reduce risks at relatively low costs;
* If appropriate, ‘urgency’–the timescales of the potential impact- can also be used as a criterion. For example, it may be better to prioritise control measures to deal with microbiological hazards which could manifest as health impacts after short exposures over those where health impacts are likely to require prolonged exposure.

A theoretical example of prioritisation is set out in Figure 6 below.

*Figure 6: Illustration of Prioritization*

As seen from the example in Fig. 6, the Control Measure 2 is more effective as it has lower cost per unit of risk impact, then this measure should be considered to implement first. *Then, the key point in this section is the Cost per Risk Impact Score for each control measure, which will be used later to rank the priority among the potential options.*

Concerning the Source of Funding, some good principles have been provided such as:

- WSP measures may be carried out, and funded by, a number of different organizations, not just WSCs.

- Funding availability needs to be assessed within integrated planning frameworks, taking account of the total envelope of financial resources and budgeted costs across different drivers.

This is quite true as clean water supply in Vietnam is considered not a pure business work, but closely related to socio-economic development in that locality. Then, all WSCs are controlled by local People’s Committee so that they can serve the local development effectively. Thus, for investment work of WSC, while some measures may be low cost or may even save money, many other measures will require significant funding, then looking for multiple resources for WSP implementation is always an important task for all WSCs.

### III.2.5 Sources of Funding

This step is symbolized as sub-step 4 (iv) in the Fig.3.

As mentioned in the previous part, funding for water supply is a part of investment for social development, then it should come from multiple resources. The key points in this section include:

* WSP measures may be carried out, and funded by, a number of different sources managed by different organisations, not just from WSC’s own budget.
* Funding availability needs to be assessed within integrated planning frameworks, taking account of the total envelope of financial resources and budgeted costs across different drivers

Then, WSP measures may be implemented by a number of organisations, not just the WSCs, and the necessary funding may come from a number of sources. Some of the most important sources for WSP implementation includes:

- WSC own capital resources, including water tariff increase: Companies which are making profit or are being equitised (i.e. converted into joint stock companies through the sale of a minority share in the company) may have capital available which they can invest in the required works. In this case, improved revenue collection or increased cost efficiency may be a means of creating this funding source by increasing the budget available for investment for a given tariff level.

- International donor grant and/or loans: There are a number of potential sources of international donor funding, including: WB, ADB, Bilateral donors such as USAID, JICA, etc.,

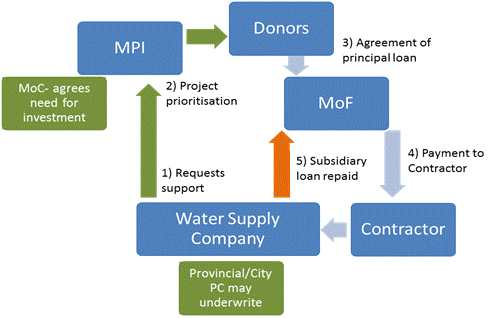
- People’s Committees/Council or other government funding: PC may finance works or subsidize WSCs where tariffs are below cost recovery. The money to do this may come from raw water charges, taxation, borrowing, etc., while rural water supply receives significant government funding, also more generally current policy allows for government funding of land use compensation and services (power supply, etc), as set out in Article 30 of Decree 117.

- Consumers ‘direct’: Interventions paid for directly by customers, such as paying for replacing household storage tanks, plumbing or supply pipes.

- Others: such as: Loans or bond issues by water supply company, i.e. to borrow money from commercial banks directly or from non-commercial institutions by WSCs; or from Private sector investment.

In the future commercial loans and private sector investmentare likely to become increasingly important if donor finance is less readily available. However, for the meanwhile, obtaining international finance is likely to be a key factor in funding major investments, although the amount available is usually rather limited.

The process for obtaining and repaying donor loans is also give in the report according to the Figure 7 below:



*Figure 7: Overview of donor funding process for urban water supply investment*

Some attention may need to be paid to the phasing of asset lives and loan maturities. If some of the assets have shorter lives than the duration of the loan (which is likely to be the case for monitoring and dosing equipment for example) being used to finance the investment, additional funding will be required when these replacements fall due.

### III.2.6 Costed Programme of Measures

This step is symbolized as sub-step 4 (v) in the Fig.3.

The goal of this step is to develop the final list of prioritized measures for WSP implementation at WSCs. The prioritized measures in this list are determined through all sub-steps from 4 (i) to 4 (iv) as described above with the help of an Excel tool (will be described in the next part). The timetable for the implementation of the measures should be programmed to take account of:

* Cost effectiveness and ‘urgency’ if appropriate;
* Feasibility (time required for project preparation, funding availability, delivery capacity i.e. procurement and management ability to implement the measures)
* The timing of the availability of financial resources identified in step 4 (iv); and
* The timing of any complementary investments (e.g. mains renewal programmes).

The output of this step is a programme of measures incorporating the timing of implementation of measures, their costs and funding availability.

## III.3 Using Excel Tool for Cost - Benefit Analysis

### III.3.1 Framework of Analysis

The tool is developed based on assumption that in practice, most of WSCs are able to forecast the need of development and all relating technical data are available. As the scope of this Guideline is to analyze in depth the cost and impact on risk of specified control measures, then the tool is also developed to serve this purpose, i.e. to help analyzing the cost of each potential CM and give the results in term of cost per impact on risk of each CM to facilitate prioritization of CMs for implementation.

Similarly to Figure 3, the tool is developed to cover the similar steps as illustrated in the Figure 7 below:



*Figure 7: Flowchart of computation for cost-benefit analysis for possible CM*

So, as indicated in the Fig 7, the tool focuses on Step 4 of WHO Manual, namely, the sub-steps from 4 (i) to 4 (iii). The expected result of the tool includes the set of possible control measures with expected Cost per Risk Impact Score for evaluation of priorities for each of them, which will be the basis for investment for implementation according to the order of priorities. This is quite important as budget for investment is usually somehow limited for a large number of WSCs, and this tool helps WSCs to know how to use their limited resources to invest in the most efficient way.

The key point in this analysis is that: all incremental costs (and benefit), as result of investment, must be standardized on basis of one (or one thousand) cubic meter of clean water produced . Without this, i.e. if we take into account only the total annualized cost of an investment option and compare it with risk riduction impact of the invested CM, people will easily get confusing between one option used for 100 thousand m3 per day and another option for 20 thousands m3 only. Then cost per unit of productivity instead of total cost is the key point for comparision of different investment options.

*The case investment for WSP accompanied with increasing productivity*:

This seems to be a special case of the original problem of “considering the effectiveness of investment for WSP implementation”, which considers only the effect of investment for improving water quality through WSP measures, implying the default assumption that the productivity remain unchanged. However, in practice, only a few of WSCs can follow this “original work”, while majority of WSCs have the requirements of increasing productivity in their investments for WSP implementation. Thus, the integration of WSP implementation into capacity expansion is a natural need of all WSCs and it would be meaningless if we separate from each other these two issues.

With the help of an Excel tool, we can solve this problem in a reasonable way based on the principle as follows:

1. To compare economic impact of the investment in comparision with “do-nothing” option. Then, we need to take into account everything relating to gain/loss (in term of economic value) and water quality (by WSP risk score);
2. According to the above rule: the economic term include: all cost of investment (Capital Expenditures – *Capex*), all operational costs (*Opex*), and incremental productivity of water (compared with the production capacity before investment) which is the main source of benefit. The hazardous risk reduction impact of the invested CM will be calculated as instructed in WHO Manual by the WSC’s WSP team.
3. Input the data into the Excel tool for producing the cash flow of an investment option along the expected life-cycle of the investment. Two kinds of results can be expected based on the intention of the investment:
   1. Investment for WSP implementation without productivity expansion (this is closest to the “original problem”, where the water safety is highlighted): We can use the tool to get the result of annualized cost/benefit per one m3 water produced per risk-reducing-score as shown in the Figure 7 above. The indicator of cost/benefit per risk impact will be used to assess the economic effectiveness of an investment option and will be used for ranking priorities among different investment options. The lower value of cost/risk indicator means the higher priority of that control measure. At the same time, we can also get the absolute value of increamental cost for ‘ensuring safety’ of one cubic meter of clean water to see if it is within the affordability of the WSC and the community as well.
   2. Investment for productivity expansion while ensuring requirements of WSP (this is likely the common tendency of most WSCs by now): In this case, we can also use the Tool for getting the result of annualized cost/benefit per one cubic meter of clean water produced. The difference from the above case is that, the risk-reducing-impact is not evident in this case. This is the usual case when the WSC has currently met basic requirements of WSP, or the current hazadous risk impact is not proven serious, then the main purpose of investment is to expand production while ensuring or improving the level of WSP just a little bit. Then, in this case, the main result the WSC expects would be the (high) benefit per one m3 water produced with an investment option provided that all requirement of WSP have been met.

Then, from the above analysis, the tool for WSIP will have to be able to serve both kinds of requirements of the WSCs in Vietnam. Fortunately, this is not a complex task as the difference (in the Excel tool) is only the input of the risk-reducing-impact of the investment option. Based on the intention of each WSC, suitable results will be obtained mainly on basis of cost-benefit assessment (maximizing the benefit while ensuring all requirements of WSP). The tool design will be explained more detailed in the next part.

### III.3.2 Tool design

This tool is designed on basis of Excel spreadsheet for facilitating data input and calculation as well as demonstration of results. The procedures of inputting data and performing calculation for both cases of “Investment for WSP implementation without productivity expansion” and “Investment for productivity expansion while ensuring requirements of WSP” are almost the same; only in the second case we may not need to input risk-reducing-impact and thus, may not need to calculate the indicator of cost/benefit per risk reducing impact for selection of prioritized CM.

The tool is designed in an open basis so that after training all WSCs can use it by inputing their own data in flexible ways for finding expected results. The steps of the tool with an illustrative example will be given below.

**A.** Investment for WSP implementation without productivity expansion:

The tool for this “first problem” includes several main parts to perform basic actions as follows:

1. Input the list of potential hazards and results of risk assessment for each hazards, including *frequency, impact* and the resulting *risk score* as instructed in WSP procedure (Step 3 of WHO Manual).
2. Input all possible control measures for abatement of those hazards with results of reassessment of the *risk score* assuming that the control measure is used (*Risk score impact*)
3. Input all data of the cash flow of the considered investment option, including: investment costs (by years), operational costs (additional, by years), additional volume of water produced (incremental revenue, by years). It is encouraged to use suitable assumptions of operational cost increase in future (due to higher labour salary, etc.), increase of water tariff (say, in the next 10-15 years), expected periodical maintenance cost along the planning horizon (say, 10-15 years), etc., to make the picture of income and expenditures as close as possible to reality.
4. Calculate the cash flow of all income and expenditures along the planning horizon.
5. Calculate the total cost (or benefit) in term of Net Present Value (NPV) per one m3 water produced in the planning period. This is the criterion for assessing the economic effectiveness of the investment option in term of production.
6. Divide the above result by *Risk Score Impact* for Cost per Risk Impact Score of the investment option. This will be used for ranking the priority of this investment among other options.
7. Summarize all options (all possible control measures) in a Summary Table and rank them by Cost per Risk Impact Scores.

An illustrative example with using this tool is given in the next part of Sample analysis.

**B.** Investment for productivity expansion while ensuring requirements of WSP

The tool for the ‘second problem’ is similar and maybe simpler than the previous one, which is consisting from step 3 to step 5 of the procedure above. The procedure is similar to the first case but the concentration is much more focused on the value of revenue of 1 m3 of water produced instead of the score of Cost/Risk impact although all requirements of WSP such as risk frequency and impacts still must be satisfied.

From the data of the investment project, we can use the Tool to calculate by the following prodedure:

1. Input the list of potential hazards and results of risk assessment for each hazards, including *frequency, impact* and the resulting *risk score* as instructed in WSP procedure (Step 3 of WHO Manual).
2. Input all possible control measures for abatement of those hazards with results of reassessment of the *risk score* assuming that the control measure is used (*Risk score impact*).
3. Input values of investment packages with corresponding expected depreciation time (in number of years). The annual payback for investment value of each package will calculated based on data of interest rate (of the loan) and number of payback installments.
4. Input all data of the cash flow of the considered investment option, including: operational costs (additional, by years), additional volume of water produced (incremental revenue, by years). It is encouraged to use suitable assumptions of operational cost increase in future (due to higher labour salary, etc.), increase of water tariff (say, in the next 10-15 years), expected periodical maintenance cost along the planning horizon (say, 10-15 years), etc., to make the picture of income and expenditures as close as possible to reality.
5. Calculate the cash flow of all income and expenditures along the planning horizon.
6. Calculate the Net Present Value (NPV) of the above cash flow, then the average annual revenue throughout the whole planning horizon.
7. Calculate annual revenue, which is the annual revenue after deducting annual payback for investment.
8. Calculate revenue per one m3 water produced in the planning period. This is the criterion for assessing the economic effectiveness of the investment option in term of production.
9. *Risk Score Impact* for Cost per Risk Impact Score of the investment option Divide can be obtained by dividing the above value (revenue of 1m3 of water) by the of risk reduction value. This will be used for ranking the priority of this investment among other options.

The advantage of this Excel tool is that, the tool is very flexible by allowing to input various assumptions of investment by several installments in different times as well as assuming rather arbitrary costs and benefits in different years instead of “fixed operational cost/benefit” during the operating years, that makes the model close to the real picture and thus makes it an ideal supporting tool for decision making.

### III.3.3 Sample analysis

The following samples will be used to illustrate the application of the Guidelines in practice for both case: investment for purely WSP implementation purpose, i.e. the WSC decides an investment just for meeting requirements of WSP without any intention of expanding the capacity of water supply, and another case where the WSC decides an investment to upgrade the system for meeting requirements of WSP but also with expanding the capacity of water supply. These two cases will be analysed by the methodology of the Guidelines with the use of Excel tool and the results are given as below.

1. A case study of investment for meeting requirement of WSP: The following is a simple example but it can show rather clearly how to use the methodology in this Guidelines to solve practical problems of investment for WSP implementation.

Risk assessment during WSP study reveals that tap water in a specific region does not have sufficient residual chlorine, that threatens the safety of tap water. One of the suggested control measures is to install an additional chlorine dosing station. The data of the suggested investment is summarized as follows:

* Total investment for the chlorine dosing station: VND1,400,000,000 which is expected to last for 7 years (appreciation in 7 years). The loan has an interest of 9% per annum.
* Annual maintenance cost is estimated as 0.5% of initial investment
* Operating cost for this station is VND3,000,000 a month.
* Average capacity of water supply for the sub-region is 5,000 m3/day with the yield of revenue water is about 95%.
* The question is: How to assess the efficiency of this investment and is the additional cost acceptable?

Additional information include:

* The current Risk score of water supplied in this sub-region due to insufficient chorine dosing is 12 (*Frequency x Impact* = *4 x 3*)
* The Risk score after the installation of this CM is 3 (*= 1 x 3*)

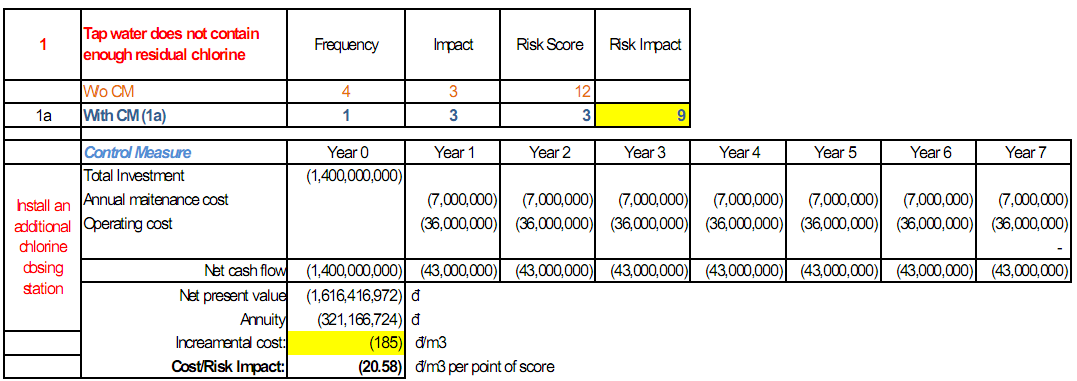
The above data are used to input to the Excel table as shown in the following figure where the input of data is performed (and calculated) by the order such as:

* The total investment is made in the year 0 (VND1.4 billions).
* Annual operating and maintenance costs are entered from year 1 to year 7.
* The Net Cash Flow is the row summing all the costs from year 0 to year 7.

Hence, the calculations include:

* Total Net Present Value, which is the sum of year 0 payment and NPV of other costs from year 1 through year 7.
* The annuity is the yearly payment for the total cost (here is the total NPV). This is the value used to evaluate the “standardized annual expense” of this control measure over the whole planning horizon.
* Increamental cost of this CM by one m3 of water supplied. This is a reference value for the decision makers to see if such additional cost affordable by current tariff or they should ask for accordingly higher water price, and finally
* The score of Cost/Risk impact.

All the above steps are shown in the Excel table as given below:



From the calculation results in the Excel table, we can see that:

* Increamental cost for ensuring water safety by this CM: VND185/m3
* Cost/Risk impact score of this CM: VND20.58

In case there is another candidate control measure, a similar calculation using the Excel tool will be repeated and the similar results of the two CMs will be compared to determine which option should be prioritized. This procedure will be repeated for other potential investment for another control measure and the final decision of investment for which CM will be based on the last two values: Increamental cost for ensuring water safety by the CM and Cost/Risk impact score of that CM.

These results are useful for the management to assess the actual incremental cost of a CM for counter treatment of the mentioned risk to see if such increase is affordable to the WSC and/or to the community in the region.

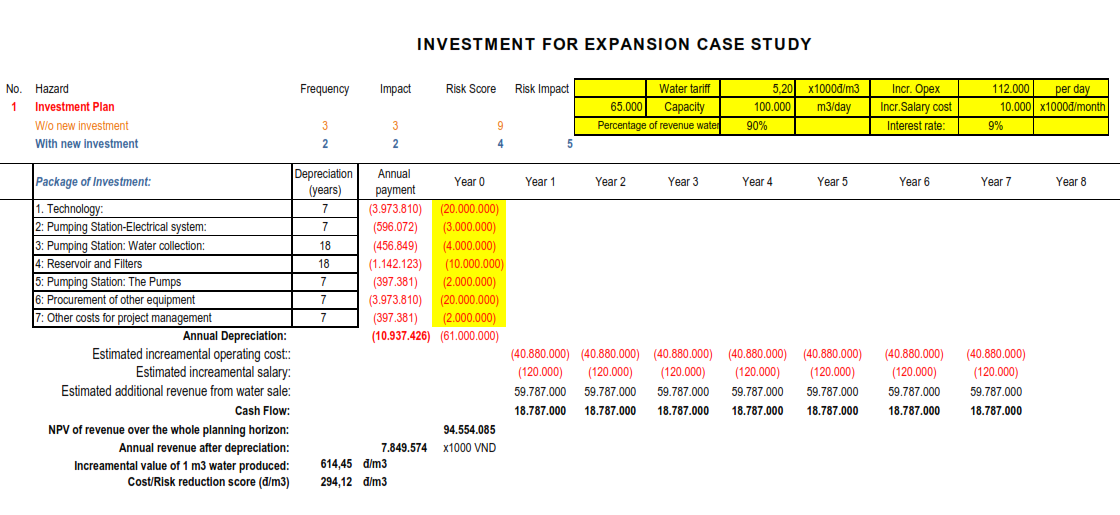
2. This Case study for the second case where the investment for upgrading WTP system accompanied with expanding production capacity is developed from an actual situation of investment in a WSC in Vietnam. In this case study, basic information of an investment project of upgrading a water treatment system in a WTP is as follows:

Information on project of upgrading a WTP to 100,000m3/day from the current capacity of 65,000 m3/day):  
Total investment of the project is VNĐ61,000,000,000, including the packages of  
    + Technology : 20,000,000,000 VNĐ  
    + Pumping Station-Electrical system: 3,000,000,000 VNĐ  
    + Pumping Station: Water collection: 4,000,000,000 VNĐ  
    + Reservoir and Filters: 10,000,000,000 VNĐ  
    + Pumping Station: The Pumps: 2,000,000,000  
    + Procurement of other equipment: 20,000,000,000 VNĐ  
    + Other costs for project management: 2,000,000,000 VNĐ  
Additional information include:

* The current Risk score of the current water supply system is 9, in average level (*Frequency x Impact* = *3 x 3*)
* The Risk score of the whole system after the upgrading project is expected as 4 (*= 2 x 2*): in acceptable level.
* The question is: How to assess the efficiency of this investment in a quantitative manner?

The answer can be found by using the tool: The above data will be entered to the Excel table as shown in the below figure. The basic steps include:

* Input the investment of each package, depreciation time (years), hence, calculate annual payback ammount of each package.
* Input all annual operating and maintenance costs along the planning horizon.
* Calculate annual revenue from water sale based on assumption of water tariff and other assumptions.
* Calculate cach flow along the years of planning,
* Calculate Total Net Present Value of the above cash flow, and the annual net revenue (after deducting annual appreciation cost).
* Calculate revenue of one m3 of water produced. This is the reference value for the decision makers to see if the investment project is beneficial, and finally
* The score of Cost/Risk impact.



Revenue of 1m3 water

Net cash flow

Other financial data

Investment items

# IV. Conclusion

The Guideline proposes a procedure to assess an investment plan for implementation of water safety plan (WSP) at the level of water supply companies (WSCs). The procedure follows the Guideline of WHO of development of WSP for WSCs with detailed break-down of some critical steps for economical analysis to assess economical feasibility of each proposed control measures (CM) to cope with each identified hazards. The WSIP appears to be important for the WSCs as the way to help them to see if their investment to WSP implementation beneficial in terms of socio-economic aspects, or from another angle, which control measures should be invested from limited available funding/loans for the best improvement in term of WSP in specific conditions at the place. The principle to solve this kind of problem is to carry out cost-benefit analysis for each intented investment during implementing WSP by the Guideline of WHO focusing on critical steps which have direct link to hazards and control measures to set up a best investment package.

A tool in form of Excel spreadsheet was developed to support the economical analysis, which provides the result in term of associated cost of each CM and corresponding cost-per-impact-on-reducing-hazard, which is the basis for deciding which CM should be implemented first for the best cost-effective impact.

This flexible tool can also be used to analyze another case of investment, which is slightly different from the original case but is currently much more popular in Vietnam, where the investment plan of a WSC accompanied with expansion of production while ensuring the requirements of WSP. By using this tool, a WSC can assess in advance the impacts of each invetsment items on the final cost of the production process as well as the final benefit received.

Examples in this guideline use typical data collected from the survey to reflect the basic concepts and methodology of assessment in common practice. A training materials have been developed to instruct WSCs to use this method of analysis using the Excel tool to develop WSIP in their own companies which can be customized for each concrete situation of investment. Then, provision of training to all WSCs so that they can use the tool to assess their own WSIP will be the most important next step.

# REFERENCES

Graydon 2010 – *Possible approaches and models of investment plan for scaling up WSP in Vietnam,* Report for WHO for the specific purpose of the Setting up of an Investment Plan Model for WSP implementation in Vietnam, 2010.

Nguyen Lanh 2012 - *Review and revise model of water safety investment plan and development of framework for action plan for WSIP phase 3 in Vietnam*, Report for WHO for the specific purpose of the Setting up of an Investment Plan Model for WSP implementation in Vietnam, 2012.

WHO 2009 – *Water Safety Plan Manual, Step-by-step risk management for drinking water suppliers*, World Health Organization 2009.