Attachment 4

Handbook for Improving Monitoring Performance

(Only in Electronic Version.)

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
SOCIALIST REPUBLIC OF VIETNAM
MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MONRE)

THE PROJECT FOR STRENGTHENING CAPACITY OF WATER ENVIRONMENTAL MANAGEMENT IN VIETNAM

HANDBOOK FOR IMPROVING MONITORING PERFORMANCE

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J I C A   E X P E R T   T E A M

SOCIALIST REPUBLIC OF VIETNAM

The Project for Strengthening Capacity of Water Environmental Management in Vietnam

Handbook for Improving Monitoring Performance

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HANDBOOK FOR IMPROVING MONITORING PERFORMANCE

CHAPTER 1 INTRODUCTION

1.1 Background

Vietnamese Government has continued to develop/revise laws, regulations, and guidelines in order to improve its water quality monitoring and analysis. To support staff under monitoring and analysis sections of target provinces (Ha Noi, Hai Phong, Thua-Thien Hue, Ho Chi Minh City, and Ba Ria-Vung Tau) keep up with such demands for improvement, the Project for Strengthening Capacity of Water Environmental Management in Vietnam (hereafter called "the Project") provided various training activities with updated/new methods. Technical skills and know-how they have gained through the Project should be used in their daily activities and passed on to other officers involved in environmental monitoring.

Also, some sections of the guidelines and manuals for water quality monitoring developed in the past, including the ones developed by JICA projects named " The Project for Enhancing Capacity of Vietnamese Academy of Science and Technology in Water Environment Protection Phase II", " The Study for Water Environment Management on River Basins in Vietnam", are already outdated. It is necessary to update the manual/guideline in accordance with the updated laws and regulations.

In this connection, "Handbook for improving water quality monitoring and analysis capacities" was prepared as a technical cooperation product in the Project. This handbook is for staff under monitoring and analysis section in provinces to improve their performance.

1.2 Purposes of the Handbook

The purposes of the handbook are as follows:

(1) to refer to technical skill and know-how on monitoring and analysis in daily activities for staff under monitoring and analysis sections in provinces, and
(2) to train new staff who is not familiar with monitoring and water quality analysis.

1.3 Expected Users of the Handbook

The expected users are:

(1) staff under monitoring and analysis sections in provinces, and
(2) staff under monitoring and analysis sections in ministries.

1.4 Ways of Usage of the Handbook

This handbook will help users carry out the following tasks:

- to prepare a water quality monitoring plan for the river water environment management (Chapter 3),
- to review and revise an existing water quality monitoring plan (Chapter 3),
- to confirm required measures on sampling to secure reliability of monitoring data (Chapter 4)
- to confirm analysis method and adopt QA/QC to secure reliability of monitoring data (Chapter 5),
- to analyze and interpret monitoring data (Chapter 6)
- to prepare effective monitoring report (Chapter 7), and
- to manage water quality monitoring data (Chapter 8).

CHAPTER 2 LEGAL FRAMEWORK RELATED TO MONITORING IN VIETNAM

2.1 Legal Framework Related to Monitoring in Vietnam

The basic framework for water quality monitoring in Vietnam is stipulated in Chapter X of Law on Environmental Protection (LEP). Chapter X describes environmental monitoring and information requirements at national level, provincial level and private sector. It stipulates the kinds of information to be collected, responsibilities, environmental monitoring systems, the kinds of report related to environmental monitoring, and the handling of environmental information. According to the law, the Provincial-level People's Committee shall organize environmental status monitoring within the Province or centrally-run city, and that provincial level specialized environmental protection agencies shall work out plans for the environmental monitoring network in their locations. The Provincial-level People's Committees is also required to submit provincial-level environmental status reports including status and changes in quality of water environment to the People's Councils and MONRE once every five years.

A National monitoring network in Vietnam was approved by Prime Minister's Decision in January 2007 (Decision No. 16 / 2007/ QD- TTg). This defines the Master plan Monitoring Network of National Natural Resources and Environment up to 2020 The monitoring network on national natural resources and environment is divided into three categories:

- environmental monitoring network,
- water resources monitoring network, and
- hydrometeorology monitoring network.

In order to create the nationwide monitoring networks by 2020, the implementation is divided into three phases

- Phase 1: 2007-2010,
- Phase 2: 2011-2015,
- Phase 3: 2016-2020

With respect to surface water quality, 60 monitoring stations form the environmental monitoring network and 270 monitoring stations form the water resource monitoring network.

Additionally, there are many legal documents on the subjects of national standards, guidelines on designing monitoring plan, sampling, analysis, QA/QC, development of database, and evaluation of monitoring data. These have been issued by MONRE and its concerned organizations to ensure proper management of water quality monitoring. The detailed outline of legal documents is shown in the Section 2.2.

2.2 Outline of Laws, Decisions, Circulars, QCVNs, and TCVNs Related to Monitoring

Table 2.2-1 is a summarized outline of laws, decisions, circulars, QCVNs, and TCVNs, related to monitoring. TCVNs on analysis methods used in laboratories are shown in Table 5.1 of Section 5.

Table 2.2-1 Outline of Laws, Decisions, Circulars, QCVNs, and TCVNs Related to Monitoring

No.	Regal Category	Organization	Issued Number	Technical Category	Title
1	Law	Government	No. 52/2005/QH11	General	Amendment of Law on Environmental protection
2	Decision	Prime Minister	No. 16 / 2007/ QD- TTg	Monitoring Plan	Master plan monitoring network on national natural resources and environment to 2020
3	Circular	MONRE	No. 29 /2011/TT-BTNMT	Monitoring Plan	Regulation on technical process of surface water environmental monitoring
4	Circular	MONRE	No. 18 /2010/TT-BTNMT	Monitoring Plan	Regulation on area, equipment & human resource for one monitoring station
5	Circular	MONRE	No. 30 /2009/TT-BTNMT	Data Management	Regulation on technical process & economical-technical limitation of development of database in natural resource & environment
6	Circular	MONRE	No. 17 /2011/TT-BTNMT	Data Analysis	Regulation on technical process of environmental map development
7	Circular	MONRE	No. 10 /2012/TT-BTNMT	QA/QC	Regulation on QA/QC in environmental monitoring
8	Decision	VEA	No. 879 /2011/QD-TCMT	Data Analysis	Guideline for calculation of water quality index
9	QCVN	MONRE	QCVN 01: 2008/BTNMT	Standard	Regulations on industrial waste water from processing natural rubber
10	QCVN	MONRE	QCVN 02:2008/BTNMT	Standard	Regulations on waste gas of medical solid incinerator
11	QCVN	MONRE	QCVN 08:2008/BTNMT	Standard	Regulation on surface water quality
12	QCVN	MONRE	QCVN 09:2008/BTNMT	Standard	Regulation on groundwater quality
13	QCVN	MONRE	QCVN 10:2008/BTNMT	Standard	Regulation on coastal water quality
14	QCVN	MONRE	QCVN 11:2008/BTNMT	Standard	Regulations on waste water of aqua product processing industry
15	QCVN	MONRE	QCVN 12: 2008/BTNMT	Standard	Regulations on waste water from paper and pulp industry
16	QCVN	MONRE	QCVN 13: 2008/BTNMT	Standard	Regulations on textile industry waste water
17	QCVN	MONRE	QCVN 14:2008/BTNMT	Standard	Regulation on domestic wastewater
18	QCVN	MONRE	QCVN 22: 2009/BTNMT	Standard	Regulations on waste gas of industry of thermal power
19	QCVN	MONRE	QCVN 28:2010/BTNMT	Standard	Regulations on medical waste water
20	QCVN	MONRE	QCVN 30:2010/ BTNMT	Standard	Regulations on waste gas of industrial waste material incinerator
21	QCVN	MONRE	QCVN 35: 2010/BTNMT	Standard	Regulations on waste water discharged from offshore petroleum projects
22	QCVN	MARD	QCVN 01/14:2010/BNNPTNT	Standard	Regulations on conditions of biosafety pig farm
23	QCVN	MARD	QCVN 02/14:2010/BNNPTNT	Standard	Regulations on conditions of biosafety poultry farm
24	QCVN	MONRE	QCVN 38:2011/BTNMT	Standard	Regulation on surface water quality for protection of aquatic lifes
25	QCVN	MONRE	QCVN 39:2011/BTNMT	Standard	Regulation on water quality for irrigated agriculture
26	QCVN	MONRE	QCVN 40:2011/BTNMT	Standard	Regulation on industrial wastewater
27	TCVN	MOST	TCVN 5996-1995	Sampling	Samples of river and spring water
28	TCVN	MOST	TCVN 5994-1995	Sampling	Samples of pond and lake water
29	TCVN	MOST	TCVN 5999-1995	Sampling	Guidance on sampling of waste water
30	TCVN	MOST	TCVN 6663-15: 2004	Sampling	Guidance to take samples as plankton
31	TCVNs	MOST	TCVNs	Analysis	Analysis methods used in laboratories (See Table 5.1)

Source: JET quoted from legal documents in Vietnam related to water quality monitoring

CHAPTER 3 DEVELOPMENT OF MONITORING PLAN

3.1 Introduction

The MONRE's Circular for regulation of the technical process of surface water monitoring (Circular No.29/2011/TT-BTNMT) provides comprehensive guidelines for the development of monitoring plans by DONREs. The Circular was issued on 1st August 2011 and became effective as of 15th September 2011. DONREs should follow the requirements of the Circular to implement surface water quality monitoring.

The Circular does not provide the detailed methodologies on how to achieve its objectives. This handbook, together with the training that has been carried out, introduces those methodologies for defining the monitoring object, selection of monitoring points, selection of monitoring determinands, setting monitoring period and frequency, and planning for implementation of monitoring in accordance with structure of the Circular.

Table 3.1-1 shows table of contents on the Circular. Among the contents of the Circular, this Chapter focuses on Articles 4 and 5 for setting of monitoring objective and designing monitoring program in the Circular related to developing monitoring and reviewing monitoring plan.

Activities for reviewing and revising monitoring plans in the Project were carried out based on the Data Quality Objectives (DQO) process taking into considering of the Circular. The DQO process; was developed by US-EPA[1] and is used to establish performance or acceptance criteria, which serve as the basis for designing a process for collecting data of sufficient quality and quantity to support the objectives of a monitoring plan. An example of actual training carried out during the Project, the review of an existing monitoring plan based on DQO process approach is show in Section 3.10.

Table 3.1-1 Table of Contents on Circular No.29/2011/TT-BTNMT
(Regulation on Technical Process of Surface Water Monitoring)

Chapter I: GENERAL PROVISIONS
Article 1. Governing scope
Article 2. Objects of application
Article 3. Principles of application of standards, invoking method
Chapter II: TECHNICAL PROCESS OF SURFACE WATER ENVIRONMENTAL MONITORING
Article 4. Objectives of monitoring
Article 5. Design of monitoring program
1. Type of monitoring
2. Monitoring locations and sites
3. Monitoring determinands
4. Time and frequency of monitoring
5. Planning for monitoring
Article 7. Implementation of monitoring programs
1. Preparation works
2. Sampling, measurement and analysis in the field
3. Storage and transportation of samples
4. Laboratory analysis
5. Data processing and reporting
Chapter III: IMPLEMENTATION
Article 8. Organization of implementation
Article 9. Implementation Effect

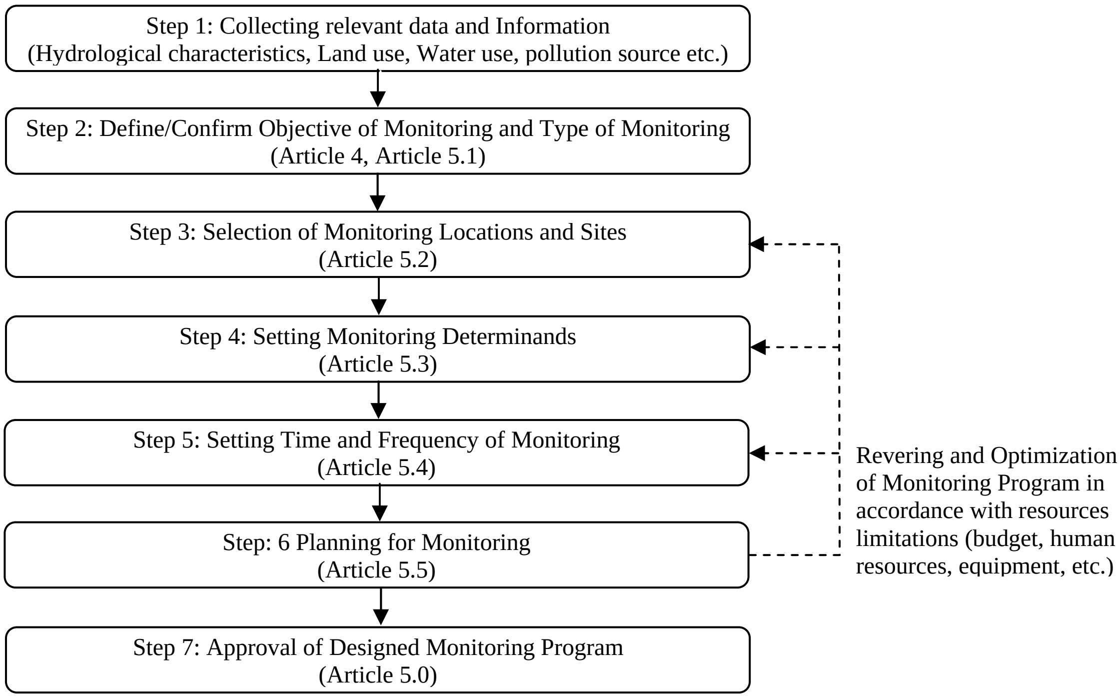
Source: Circular No.29/2011/TT-BTNMT for regulation on technical process of surface water monitoring

3.2 Procedure of Development of Monitoring Plan

The Circular guides two fields for development of monitoring plan; objective of monitoring program (Article 4) and design of monitoring program (Article 5). In particular, Article 5 covers most of the process for the development of monitoring such as type of monitoring, monitoring locations and sites, monitoring determinands, time and frequency of monitoring, planning for monitoring. Thus this handbook describes technical guidance of each step for developing monitoring plan in accordance

[1] Guidance for the Data Quality Objectives Process. EPA QA/G-4. EPA/600/R-96/055. United States Environmental Protection Agency. Office of Research and Development. Washington DC 20460. September 1994.

with contents of Article 5. The handbook sets out seven steps in the procedure for developing monitoring plan as shown in Figure 3.2.1. Of the seven steps, six steps are described in the Circular, only first step, that of assembling and reviewing relevant background data, is added to the handbook.



Source: JET quoted from Circular No.29/2011/TT-BTNMT for regulation on technical process of surface water monitoring

Figure 3.2-1 Procedure of Preparation of Monitoring Plan

3.3 Step 1: Collection of Relevant Data and Information

In order to develop an effective monitoring plan, relevant background data and information should be collected and validated. Examples of such data and information are data and information on

- hydrological structure,
- any previous water quality monitoring results,
- water use,
- pollution source, and
- land use.

These are essential for the setting the locations of monitoring stations, determining monitoring determinands, and monitoring frequency as shown in Table 3.3-1. In addition, information and data on available human resources available for monitoring, equipment for sampling and analysis, accessibility to monitoring stations and budget are also required.

Table 3.3-1 Collection of Relevant Data and Information to be Required

Factors	Necessary Information and Data
Hydrological information	Topography, river structure, river flow (discharge, water level, velocity), rainfall, tidal cycle
Water quality	Past water quality monitoring data
Water use condition	Irrigation, domestic, and industrial water uses, recreation activity, aquaculture and fishery
Pollution sources	Factories, mining areas, craft villages, hospitals and solid waste dumping sites, aquatic farm etc.
Land use	Forestry and mangrove, grassland and shrub, paddy field, agricultural field, urban area, aquatic farm

Source: JET

3.4 Step 2: Define/Confirm Objectives of Monitoring and Type of Monitoring (Article 4, Article 5.1)

3.4.1 Objective of Monitoring

According to Article 4 in the Circular, The fundamental objectives of surface water environmental monitoring are:

1. To assess the current conditions of surface water quality in the region or locality;
2. To assess the suitability of the allowable standards for water environment;
3. To assess the changes in water quality over time and space;
4. To give early warnings of the consequences of water pollution;
5. To follow other requirements of environmental management at national, regional and local levels.

As shown in the above box, there are five fundamental objectives for monitoring. In addition to the fundamental monitoring objectives, two supplementary objectives are also required especially in a polluted area which could affect water sources.

Information relating to each objective that is obtained, based on monitoring results, contributes to the effectiveness of water quality management. Table 3.4-1 summarizes shows relationship between objective of monitoring and way of usage for water quality management.

Table 3.4-1 Relationship between Objective of Monitoring and Way of Usage for Water Quality Management

Objectives of Monitoring	Information to be Obtained	Way of Usage for Water Quality Management
1. To assess the current conditions of surface water quality in the region or locality	Typical water quality in river basin	To set goals for river basin management plan
2. To assess the suitability of the allowable standards for water environment	Comparison results of actual water quality and water quality standards	To select priority area to implement countermeasures
3. To assess the changes in water quality over time and space	Trend of water quality	To identify effectiveness of management strategy
4. To give early warnings of the phenomena of water pollution;	Unusual river water monitoring data in accidental case	To find source of accidental discharge and to inform to the relevant
5. To follow other requirements of environmental management at national, regional and local levels	Comparison with results of water quality before and after countermeasures	To evaluate effectiveness of countermeasures for pollution control
6. To identify area with serious pollution source	Water quality monitoring data at the area affected by discharge of wastewater	To select priority area to implement countermeasures
7. To grasp amount of pollutants	Amount of pollutants in river water	To evaluate impact of pollution load to rivers

Source: JET

3.4.2 Type of monitoring

According to Article 5.1 in the Circular, based on objectives of monitoring, when designing monitoring programs it is required to determine whether the type of monitoring is baseline environmental monitoring or environmental impact monitoring.

As shown in the above box, there are two types of monitoring;

- baseline environmental monitoring and
- environmental impact monitoring.

In reality, environmental impact monitoring can be divided into two sub-categories;

- monitoring for pollution control and
- monitoring for water usage control.

3.5 Step 3: Selection of Monitoring Locations and Sites (Article 5.2)

According to Article 5.2 in the Circular, three guidelines are required as follows;

a) The identification of surface water monitoring locations depends on the overall objectives of monitoring program and the specific conditions of each monitoring site;

b) Based on the requirements of the type of water body to be monitored (rivers, streams, ponds, lakes etc.), the network of monitoring locations will be developed accordingly. The number of monitoring points to be employed shall be determined yearly by a competent authority;

c) Location of monitoring points should be selected careful, to ensure that they are representative of the water environment in place of monitoring. The identity and exact coordinates recorded and marked on the map.

Within the three guidelines shown in the above box, the identification of monitoring locations shall be described more detail in accordance with the three possible types of monitoring. Detailed guidance for selection of monitoring location and sites are shown in below. Figure 3.2-2 shows how the various monitoring points differ.

(1) Baseline Environmental Monitoring Points (Baseline Points)

Baseline environmental monitoring sites shall be set to obtain baseline conditions and establish any trend of water quality, and to measure pollution loads. The baseline points are required to measure the same determinands at specified locations from upper to lower reaches of the river. Therefore, the baseline points are for establishing long term chronic and spatial trends of water quality from the upper to lower reaches in a river basin level.

The other objective of baseline points is estimating pollution loads distribution. By measuring the pollution load (pollutant concentration x discharge rate) near provincial borders and confluence points of tributaries, the amount of pollution loads from pollution sources could be obtained at Provincial level and sub-basin level.

For these objectives, the baseline points should be established at the following locations.

1) Upper reach of the mainstream,
2) Points measuring water flow or water level,
3) Points where there are changes in water flow conditions, such as upstream and downstream of a confluence point of a tributary, or inflow to and outflow from a closed water area,
4) Estuary or lower reach of a river, and
5) Near provincial boundary.

(2) Monitoring Points for Pollution Control (Pollution Control Point)

Each monitoring point (three categories) have objective to identify and to quantify the impacts of a pollution source. Pollution control points shall focus on this function especially. In order to identify impacts caused by pollution sources such as factories, mines, hospitals and waste disposal sites whose leachate contain heavy metals and other toxic materials, pollution control points are required at both upstream and downstream of the pollution sources. In order to ensure representative sampling the points must be below the fully mixed boundary of the pollution source. The determinands measured should be selected taking into consideration the type of pollution source. When hazardous impacts are to be monitored, the specific pollution sources should be identified through the use of the Pollution Source Inventory (PSI).

For these objectives, the Pollution Control points should be set at the following locations.

1) Upstream and downstream in relation to the discharge points of wastewater affecting river water quality
2) Inflow point of tributary system that contains critical areas within the tributary sub-basin.
   However, when the tributary contribute a significant proportion of the combined river flow the

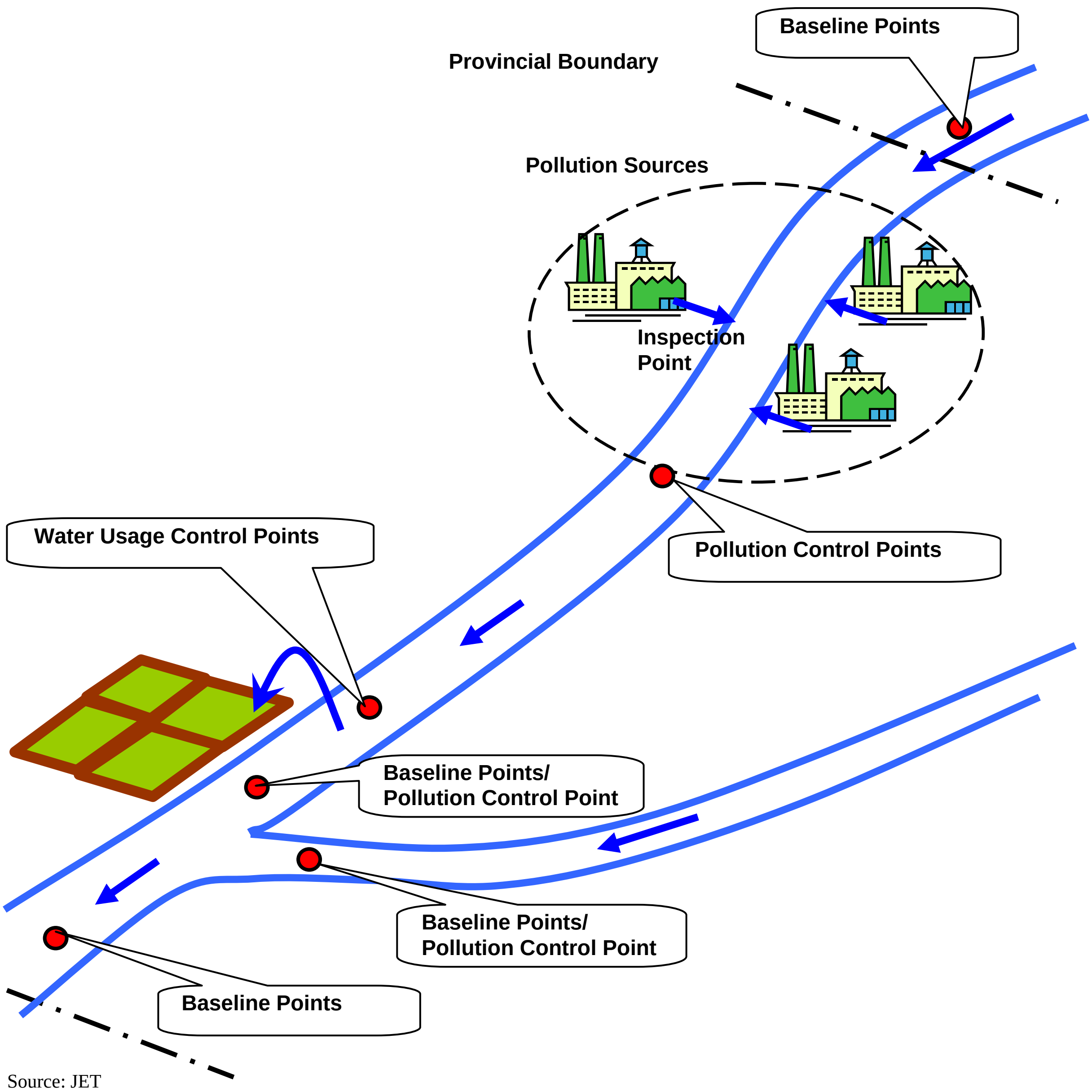
monitoring station should be established as a baseline monitoring point. In such a case the monitored determinands should be selected not only as those for a reference station but also as a pollution control station.)

(3) Monitoring Points for Monitoring for Water Usage Control (Water Usage Control Points)

In order to evaluate suitability of the river for a particular water use, water usage control points are set at upstream points of water intake. Its determinands should be selected from those applicable to the specific water use. When hazardous impacts are to be considered at the water usage control points, pollution sources should be identified through the process as well as pollution control points.

For these objectives, the Water Usage Control points should be set at the following locations.

1) Upstream point of water intake facility



Source: JET

Figure 3.5-1 Setting of Water Quality Monitoring Points

3.6 Step 4: Setting Monitoring Determinands

According to Article 5.3 in the Circular, types of water sources, purposes of use, pollution sources or receiving facilities, the following determinands will be monitored in accordance with objectives of the monitoring program;

a) The determinands to be measured and analyzed in the field:
pH, temperature (t_0), dissolved oxygen (DO), electrical conductivity (EC), turbidity, total dissolved solids (TDS);

b) Other determinands:
color, redox (Eh or ORP), total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), nitrite (NO_2^-), nitrate (NO_3^-), ammonium (NH_4^+), sulphate (SO_4^{2-}), phosphate (PO_4^{3-}), total nitrogen (T-N), total phosphorus (T-P), silica (SiO_3^{2-}), total iron (Fe), chloride (Cl-), fluoride (F-), alkalinity, coliform, *E.coli*, faecal coliforms, cyanide (CN^-), silica (SiO_2), oil, grease, arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), zinc (Zn), copper (Cu), nickel (Ni), manganese (Mn), sodium ions (Na^+), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}), phenol, surface-active substances, residues of plant protection chemicals, plankton and benthos;

c) Depending on the availability of equipment, manpower for monitoring, some determinands specified at Point b, Clause 3 of this Article may be quickly measured on-site.

As shown in the above box, the required determinands are mostly covered by QCVN 08: 2008/ BTNMT Surface water standard as shown in Table 3.6-1. However the required determinands at each type of monitoring are not defined clearly. Thus the handbook guides how to select determinands for all types of monitoring and determinands for each type of monitoring; baseline point, pollution control point, and water usage control points.

Table 3.6-1 Surface Water Quality Standard (QCVN 08: 2008/ BTNMT)

No.	Determinands	Unit	Limit value			
			A		B	
			A1	A2	B1	B2
1	pH	-	6-8.5	6-8.5	5.5-9	5.5-9
2	DO	mg/l	≥6	≥5	≥4	≥3
3	Total SS	mg/l	20	30	50	100
4	COD	mg/l	10	15	30	50
5	BOD_5 (20°C)	mg/l	4	6	15	25
6	Ammonia (NH^+_4 as N)	mg/l	0.1	0.2	0.5	1
7	Chloride (Cl^-)	mg/l	250	400	600	-
8	Fluoride(F^-)	mg/l	1	1.5	1.5	2
9	Nitrite (NO^-_2)	mg/l	0.01	0.02	0.04	0.05
10	Nitrate (NO^-_3)	mg/ l	2	5	10	15
11	Phosphate (PO^{3-}_4)	mg/l	0.1	0.2	0.3	0.5
12	Cyanide (CN^-)	mg/l	0.005	0.01	0.02	0.1
13	Asenic (As)	mg/l	0.01	0.02	0.05	0.1
14	Cadmium (Cd)	mg/l	0.005	0.005	0.01	0.01
15	Lead (Pb)	mg/ l	0.02	0.02	0.05	0.05
16	Cromium III ($Cr^{3+)}$)	mg/l	0.05	0.1	0.5	1
17	Cromium VI ($Cr^{5+)}$)	mg/l	0.01	0.02	0.04	0.05
18	Copper (Cu)	mg/l	0.1	0.2	0.5	1
19	Tin (Zn)	mg/l	0.5	1.0	1.5	2
20	Nickle (Ni)	mg/ l	0.1	0.1	0.1	0.1
21	Iron (Fe)	mg/l	0.5	1	1.5	2
22	Mercury (Hg)	mg/l	0.001	0.001	0.001	0.002
23	Surface active material	mg/l	0.1	0.2	0.4	0.5
24	Oil and grease	mg/l	0.01	0.02	0.1	0.3
25	Phenol (total)	mg/l	0.005	0.005	0.01	0.02
26	Pesticide chemical- organic Clo	µg/l				
	Aldrin +dieldrin	µg/l	0.002	0.004	0.008	0.01
	Endrin	µg/l	0.01	0.012	0.014	0.02
	BHC	µg/l	0.05	0.1	0.13	0.015
	DDT	µg/l	0.001	0.002	0.004	0.005
	Endosunfan (Thiodan)	µg/l	0.005	0.01	0.01	0.02
	Lindane	µg/l	0.3	0.35	0.38	0.4
	Chlordane	µg/l	0.01	0.02	0.02	0.03
	Heptachlor	µg/l	0.01	0.02	0.02	0.05
27	Pesticide chemical-organic phosphor					
	Parathion	µg/l	0.1	0.2	0.4	0.5
	Malathion	µg/l	0.1	0.32	0.32	0.4
28	Herbicide chemical					
	2,4D	µg/l	100	200	450	500
	2,4,5T	µg/l	80	100	160	500
	Paraquat	µg/l	900	1200	1800	2000
29	Total of radioactive activity α	Bq/l	0.1	0.1	0.1	0.1
30	Total of radioactive activity β	Bq/l	1.0	1.0	1.0	1.0
31	*E.coli*	MPN/100ml	20	50	100	200
32	Coliform	MPN/100ml	2500	5000	7500	10000

Note: the classification of surface water aims to assess and control water quality, serving different uses of water:
A1- good for domestic water supply purpose and other purposes as of A2, B1 and B2
A2- for domestic water supply purpose, but suitable treatment technology must be applied; conservation of aquatic life, or other purposes of B1 and B2
B1- for irrigation purpose or other purposes with demand for similar quality water or other purpose of B2
B2- for water transportation and other purposes with demand for low-quality water

(1) Common Determinands for all types of Monitoring

Physical, organic, nutrient, and bacteria determinands are basic ones to monitor surface water quality. These determinands respond sensitively to river flow, temperature, condition of wastewater discharge. Water Quality Index (WQI), which is stipulated in VEA Decision No. 879/QD-TCMT Guideline on calculation of WQI of surface water environmental monitoring, also requires to monitor physical, organic, nutrient, and bacteria determinands. In this connection, the handbook recommends to monitor determinands related to physical, organic, and nutrient for all types of monitoring as shown in Table 3.6-2.

Table 3.6-2 Common Determinands to be Monitored for all Type of Monitoring

No.	Category	Determinands	WQI	QCVN 08: 2008	Other key Determinands
1	Physical	pH		√	
2		Electrical Conductivity			√
3		Temperature	√		
4		DO	√	√	
5		Total of SS	√	√	
6		Turbidity	√		
7	Organic	COD	√	√	
8		BOD_5 (20°C)	√	√	
9	Nutrient	Ammonia (NH^+_4) (calculating based on N)	√	√	
10		Nitrit (NO^-_2)		√	
11		Nitrat (NO^-_3)		√	
12		Phosphat (PO^{3-}_4)	√	√	
13	Bacteria	E.Coli		√	
14		Coliform	√	√	

Source: JET

(2) Determinands for Baseline Environmental Monitoring Points (Baseline Points)

One of the important objectives for baseline environmental monitoring points is to understand how much concentration comes from upstream (or confluence) and discharges to downstream (or main stream) through checking water quality at boundary of provinces. In this connection, the handbook recommends to monitor maximum determinands in addition to common determinands for all types of monitoring in the beginning stage: a few years after setting monitoring stations.

After the beginning stage, the maximum determinands that will be significantly meeting the standard and those that will be grossly failing to meet the standard need little attention from a statistical point of view. It is recommendable to check the confidence of failure or meeting of the standard for those whose annual means are within say ±20% of the requisite standard. If a previously compliant mean crosses the limit it is appropriate to determine the level of confidence that it was meeting the standard and similarly what is the level of confidence that it is failing the standard. Based on the checking failure or meeting of the standard, monitoring determinands can be optimized to focus on key determinands at important stations and to increase monitoring stations or frequency by reducing monitoring determinands that are significantly meeting the standard.

(3) Determinands of Monitoring Points for Pollution Control (Pollution Control Point)

Determinands for pollution control monitoring points shall depend on what kinds of industries are existing upstream of monitoring point. The MONRE Circular No. 04/2012/TT-BTNMT: Specifying criteria to determine the facility causing environmental pollution, sever environmental pollution stipulates specific environmental determinands to monitor wastewater of 85 types of facilities in 25 sectors based on national technical regulation on wastewater of some sectors as shown in Table 2.2-1. Table 3.6-4 summarizes determinands for monitoring points for pollution control.

(4) Determinands of Monitoring Points for Water Usage Control (Water Usage Control Points)

1) Domestic Water Sources

Determinands of monitoring points for domestic water usage control shall be followed by QCVN 08:2008 as shown in Table 3.6-3. In some regions water from rivers and lakes/reservoirs is used for drinking without treatment. In other areas, it is treated and/or disinfected before use. In both cases, determinands having potential risks to human health should be monitored. The standards for maximum allowable concentrations in drinking water have been set by TCXDVN-33 2006: Water supply - distribution system and facilities, design standard. However some DONREs do not have enough capabilities on analyzing the required determinands. Thus this handbook recommends to monitor minimum required determinands based on common determinands for all types of monitoring, some toxic determinands, basic determinands as shown in Table 3.6-4.

Table 3.6-3 Determinands of Monitoring Points for Domestic Water Source (Minimum Requirement)

No.	Category	Determinands	WQI	QCVN 08: 2008	Other key determinands
1	Physical	Ph		√	
2		Electrical Conductivity			√
3		Temperature	√		
4		DO	√	√	
5		Total of SS	√	√	
6		Turbidity	√		
7		Color			√
8		Odor			√
9		Hardness			√
10	Organic	COD	√	√	
11		BOD_5 (20°C)	√	√	
12	Nutrient	Ammonia (NH^+_4) (calculating based on N)	√	√	
13		Nitrit (NO^-_2)		√	
14		Nitrat (NO^-_3)		√	
15		Phosphat (PO^{3-}_4)	√	√	
16	Toxic	Fluoride (F^-)		√	
17		Cyanogen (CN^-)		√	
18		Cadmium (Cd)		√	
19		Arsenic (As)		√	
20		Lead (Pb)		√	
21		Hexavalent Chrome (Cr^{6+})		√	
22		Mercury (Hg)		√	
23	Bacteria	E.Coli		√	
24		Coliform	√	√	

Source: JET

Table 3.6-4 Determinands for Monitoring Points for Pollution Control stipulated in CircularNo.04/2012/TT-BTNMT (1/3)

Analysis Parameter	pH	Temparature	Color	BOD_5	COD	SS	As (Asenic)	Hg (Mercury)	Pb (Lead)	Cd (Cadmium)	Cr^{6+} (Chromium hexavalent)	Cr^{3+} (Chromium trivalent)	Cu (Copper)	Zn (Zinc)	Ni (Nickel)	Mn (Manganese)	Fe (Iron)	Sn (Tin)	CN (Cyanide)	Phenol	Oil and grease	Chlorine residue	PCBs	Organophosphrous	Organochlorine	Sulfar	Fluoride	Chloride	Total Nitrogen (T-N)	Ammonium (NH_4-N)	Nitrate (NO_3-N)	Total Phosphorous (T-P)	Phosphate (PO_4-P)	Coliform	Gross α activity	Gross β activity	Notes
Industrial Sector	Analysis Parameters Specified on "Circular No.04/2012/TT-BTNMT"																																				Notes
1. Textile and Garment																																					QCVN 13
Dying units	x	x	x	x	x	x					x	x	x		x	x	x	x			x	x							x			x					
Garment units	x	x	x	x	x	x					x	x	x		x	x	x	x			x	x							x			x					
Textile unit	x	x	x	x	x	x					x	x	x		x	x	x	x			x	x							x			x					
Bleaching unit	x	x	x	x	x	x					x	x	x		x	x	x	x			x	x							x			x					
2. Beverage and foodstuff																																					
Confectionary	x	x	x	x	x	x																							x			x		x			
Brewing, beer	x	x	x	x	x	x																							x			x		x			
Dairy	x	x	x	x	x	x																							x	x		x		x			
Canned food	x	x	x	x	x	x															x					x		x	x	x		x					
Soft drink, mineral water	x	x	x	x	x	x															x					x		x	x	x		x					
Cooking oil	x	x	x	x	x	x															x					x		x	x	x		x					
3. Mineral exploitation																																					
Construction materials	x	x	x	x	x	x																							x			x			x	x	
Metal mineral	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x								x			x					
Coal mining	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								x			x					
Oil and natural gas offshore	x	x	x	x	x	x															x								x			x					QCVN 35
4. Ferric products production units																																					
Metallurgy	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x								x			x					
Mechanic assembly	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x								x			x					
Metal recycling units	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x								x			x					
Metal plating	x	x	x	x	x	x					x	x	x	x	x		x		x	x									x	x		x					
Metal recycling from metallurgy process	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x								x			x					
Electronic spare parts	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x								x			x					
Metal casting	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x			x					
5. Mineral producing																																					
Chemical process	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x		x	x		x			x	x	
Non-chemical process	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x											x			x			x	x	
6. Leather processing	x	x	x	x	x	x					x	x									x					x			x			x					
7. Paper and pulp production	x	x	x	x	x	x																				x			x			x					QCVN 12 (AOX)
8. Chemical production																																					
Chemical production	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								x	x		x					
"Urea" fertilizer	x	x	x	x	x	x	x													x	x						x		x	x		x					
Phosphate	x	x	x	x	x	x																					x		x			x			x	x	

Table 3.6-4 Determinands for Monitoring Points for Pollution Control stipulated in CircularNo.04/2012/TT-BTNMT (2/3)

Analysis Parameter	Analysis Parameters Specified on "Circular No.04/2012/TT-BTNMT"																																				Notes
Industrial Sector	pH	Temparature	Color	BOD_5	COD	SS	As (Asenic)	Hg (Mercury)	Pb (Lead)	Cd (Cadmium)	Cr^{6+} (Chromium hexavalent)	Cr^{3+} (Chromium trivalent)	Cu (Copper)	Zn (Zinc)	Ni (Nickel)	Mn (Manganese)	Fe (Iron)	Sn (Tin)	CN (Cyanide)	Phenol	Oil and grease	Chlorine residue	PCBs	Organophosphorus	Organochlorine	Sulfar	Fluoride	Chloride	Total Nitrogen (T-N)	Ammonium (NH_4-N)	Nitrate (NO_3-N)	Total Phosphorus (T-P)	Phosphate (PO_4-P)	Coliform	Gross α activity	Gross β activity	
Melt phosphate	×	×	×	×	×	×																					×		×			×			×	×	
Super phosphate	×	×	×	×	×	×																					×		×			×			×	×	
Oil chemical filter unit	×	×	×	×	×	×														×	×								×			×					
Petroleum storage	×	×	×	×	×	×															×								×			×					
Petro-chemical (surface activate, plastic chemical)	×	×	×	×	×	×													×	×	×								×			×					
Gas station	×	×	×	×	×	×															×								×			×					
Cleanser and detergent	×	×	×	×	×	×													×	×		×							×			×					
Cosmetic chemical. Pharmaceucical products	×	×	×	×	×	×													×	×		×							×			×					
Plastic manufacturing	×	×	×	×	×	×													×	×		×							×			×					
9. Rubber, latex production																																					
Rubber, latex	×	×	×	×	×	×																							×	×		×					QCVN 01
Footwear, rubber tyre	×	×	×	×	×	×													×	×		×							×			×					
10. Glass production	×	×	×		×	×													×	×		×							×			×					
11. Ceramic production	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×									×		×			×					
12. Electric production																																					
Thermal power	×	×																											×			×					
Battery production	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×								×	×		×					
Dry-cell battery	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×								×	×		×					
13. Industry with combustion process																																					
Usage of fuel oil	×	×	×		×	×															×								×			×					
Usage of coal/woods	×	×	×		×	×													×	×									×			×					
Usage of cashew nuts	×	×	×		×	×													×	×									×			×					
14. Agricultural product processing																																					
Suger production	×	×	×	×	×	×																				×	×		×			×		×			
Coffee processing	×	×	×	×	×	×																							×			×		×			
Cassava powder	×	×	×	×	×	×													×			×				×	×		×	×		×		×			
Cashew nut	×	×	×	×	×	×														×									×			×					
Vegitable and bulb	×	×	×	×	×	×																						×	×			×					
Seasoning powder	×	×	×	×	×	×													×	×									×			×					
Livestockl feedings	×	×	×	×	×	×																				×			×	×		×		×			
Cerial grain	×	×	×	×	×	×																							×			×		×			
Tea manufacturing	×	×	×	×	×	×																							×			×		×			
Bamboo and woody processing	×	×	×	×	×	×														×									×			×					

Table 3.6-4 Determinands for Monitoring Points for Pollution Control stipulated in CircularNo.04/2012/TT-BTNMT (3/3)

Analysis Parameter / Industrial Sector	pH	Temparature	Color	BOD_5	COD	SS	As (Asenic)	Hg (Mercury)	Pb (Lead)	Cd (Cadmium)	Cr^{6+} (Chromium hexavalent)	Cr^{3+} (Chromium trivalent)	Cu (Copper)	Zn (Zinc)	Ni (Nickel)	Mn (Manganese)	Fe (Iron)	Sn (Tin)	CN (Cyanide)	Phenol	Oil and grease	Chlorine residue	PCBs	Organophosphprous	Organochlorine	Sulfar	Fluoride	Chloride	Total Nitrogen (T-N)	Ammonium (NH_4-N)	Nitrate (NO_3-N)	Total Phosphorous (T-P)	Phosphate (PO_4-P)	Coliform	Gross α activity	Gross β activity	Notes
	Analysis Parameters Specified on "Circular No.04/2012/TT-BTNMT"																																				
Handcraft unit	x	x	x	x	x	x																															
15. Organic, bio-fertilizer	x	x	x	x	x	x																							x			x		x			
16. Livestock and poultry farming																																					
Livestock/poultry raising	x	x	x	x	x	x																				x			x	x		x		x			Total & Fecal coliform and Salmonella
Slaughtering	x	x	x	x	x	x															x					x			x	x		x		x			
17. Pesticide storage	x	x	x		x	x														x				x	x												
18. Waste treatment facility																																					
Solid waste treatment unit	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x	x		x		x			
Hazardous waste dumping	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x	x		x		x			
Temporal waste storage	x	x	x	x	x	x																							x	x		x		x			
Waste incineration	x	x	x	x	x	x																							x			x					
Centralized wastewater treatment plant	x	x	x	x	x	x																							x			x		x			
19. Construction material production																																					
Brick, tile,cement, etc	x	x	x		x	x																															
Concrete	x	x	x		x	x																															
20. Fisheries and aquaculture																																					QCVN 11
Aquaculture farms	x	x	x	x	x	x															x	x							x	x				x			
Fish processing unit	x	x	x	x	x	x															x	x							x	x				x			
Fish feedings	x	x	x	x	x	x															x	x							x	x				x			
21. Hospital, health center	x	x		x	x	x														x									x	x	x	x	x	x	x	x	QCVN 28 (pathogen)
22. Transportation																																					
Automobile and motorbike manufacturing	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x			x								x			x		x			
Bus stop, airport	x	x	x		x	x															x								x	x		x		x			
Car washing service	x	x	x		x	x															x								x			x		x			
Shipbuilding and repairing	x	x	x		x	x														x	x								x			x					
Ship scrapping	x	x	x		x	x															x								x			x		x			
Sea and river port	x	x	x		x	x															x								x			x		x			
23. Tourism																																					
Hotel and restaurant	x	x	x	x	x	x															x					x			x	x	x	x	x	x			QCVN 14 (Surfactants)
Resort, golf course	x	x	x	x	x	x															x					x			x	x	x	x	x	x			
Hot spring area	x	x	x	x	x	x															x								x	x		x		x			
24. Institute, laboratory	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								x			x		x	x	x	

2) Irrigation

Irrigation water contaminated by pathogens and toxic compounds has potential health risk to food consumers. The presence of certain inorganic ions can also affect the soil quality, and affect growth of the crops. Irrigation water quality standard is stipulated by QCVN 39: 2011/BTNMT: Regulation for water quality for irrigated agriculture. Table 3.6-5 summarizes the determinands to be monitored on irrigation water.

Table 3.6-5 Determinands of Monitoring Points for Irrigation

No.	Category	Determinands	WQI	QCVN 39: 2008	Other key Determinands
1	Physical	pH		√	
2		Electrical Conductivity			√
3		Temperature	√		
4		DO	√	√	
5		Total of SS	√		
6		Turbidity	√		
7		Dissolved Solid		√	
8	Inorganic Substance	Boron (B)		√	
9		SAR		√	
10		Sulfide (SO_4^{2-})		√	
11		Chloride (Cl^-)		√	
12	Organic	COD	√		
13		BOD_5 (20°C)	√		
14	Nutrient	Ammonia ($NH^+_{4)}$ (calculating based on N)	√		
15		Nitrit (NO^-_2)			√
16		Nitrat (NO^-_3)			√
17		Phosphat (PO^{3-}_4)	√		
18	Toxic	Arsenic (As)		√	
19		Cadmium (Cd)		√	
20		Total Chrome (Cr)		√	
21		Mercury (Hg)		√	
22		Copper (Cu)		√	
24		Lead (Pb)		√	
24		Zinc (Zn)		√	
25	Bacteria	Coliform	√		
26		Fecal Coliform		√	

Source: JET

3) Aquatic Life in Surface Water

Aquatic organisms have various requirements on surface water quality. Amount of available oxygen and nutrients and existence of toxic chemicals affect growth and reproduction of aquatic organisms. In Vietnam, contaminated water might affect aquatic life and cause fishkill sometime. In order to keep proper surface water quality for aquatic life, a standard is stipulated by QCVN 38: 2011/BTNMT: Regulation on surface water quality for protection of aquatic lifes. Table 3.6-6 summarizes the determinands to be monitored for aquatic life.

Table 3.6-6 Determinands of Monitoring Points for Aquatic Life Water Usage (Surface Water)

No.	Category	Determinands	WQI	QCVN 38: 2008	Other key Determinands
1	Physical	pH		√	
2		Electrical Conductivity			√
3		Temperature	√		
4		DO	√	√	
5		Total of SS	√	√	
6		Turbidity	√		
7		Dissolved Solid		√	
8	Organic	COD	√		
9		BOD_5 (20°C)	√		
10	Nutrient	Ammonia ($NH^{+}{}_{4)}$ (calculating based on N)	√	√	
11		Nitrit (NO_2^-)		√	√
12		Nitrat (NO_3^-)		√	√
13		Phosphat (PO_4^{3-})	√		
14	Toxic	Cyanide (CN^-)		√	
15		Arsenic (As)		√	
16		Cadmium (Cd)		√	
17		Hexavalent Chrome (Cr^{6+})		√	
18		Mercury (Hg)		√	
19		Copper (Cu)		√	
20		Lead (Pb)		√	
21		Phenol (Total)		√	
22	Pesticide chemical-organic Cl	Aldrin		√	
23		Chlordane		√	
24		DDT		√	
25		Dieldrin		√	
26		Endrin		√	
27		Heptachlor		√	
28		Toxaphene		√	
29	Herbicide chemical	2,4D		√	
30		2,4,5T		√	
31		Paraquat		√	
32	Bacteria	Coliform	√		
33		Fecal Coliform			√
34	Oil & Surfactant	Oil & Grease		√	
35		Surface-active substances		√	

Source: JET

4) Aquaculture and Recreation in Coastal Water

Water use for recreation activities has possibility to give health risk if the water has pathogens. Water quality standard for aquaculture, aquatic conservation, beaches, water sports is stipulated by QCVN 10: 2008/BTNMT: Regulation for water quality for coastal water quality. Table 3.5-7 summarizes the determinands to be monitored on irrigation water.

Among required determinands in Table 3.6-7, odor, total suspended solids (turbidity), electrical conductivity, pH, dissolved oxygen (DO), oil & grease, and total coliform are more important determinands to monitor aquaculture and recreation in coastal water.

Table 3.6-7 Determinands of Monitoring Points for Aquaculture and Recreation Water Usage (Coastal Water)

No.	Category	Determinands	QCVN 38: 2008	Other key Determinands
1	Physical	pH	√	
2		Electrical Conductivity		√
3		Temperature	√	
4		DO	√	
5		Total of SS	√	
6		Turbidity		√
7		Dissolved Solid	√	
8	Inorganic Substance	Fluoride (F^-)	√	
9		Sulfur (S^{2-})	√	
10	Organic	COD ($KMnO_4$)	√	
11	Nutrient	Ammonia (NH^+_4) (calculating based on N)	√	
12	Toxic	Cyanide (CN^-)	√	
13		Arsenic (As)	√	
14		Cadmium (Cd)	√	
15		Trivalent Chrome (Cr^{3+})	√	
16		Hexavalent Chrome (Cr^{6+})	√	
17		Mercury (Hg)	√	
18		Copper (Cu)	√	
19		Lead (Pb)	√	
20		Zinc (Zn)	√	
21		Manganese (Mn)	√	
22		Iron (Fe)	√	
23		Phenol (Total)	√	
24	Pesticide chemical-organic Cl	Aldrin/dieldrin	√	
25		Endrin	√	
26		BHC	√	
27		DDT	√	
28		Endosunfan (Thiodan)	√	
29		Lindan	√	
30		Chlordane	√	
31		Heptachlor	√	
32	Pesticide chemical-organic phospho	Paration	√	
33		Malation	√	
34	Radioactive activity	Total of radioactive activity α		
35		Total of radioactive activity β		
36	Herbicide chemical	2,4D	√	
37		2,4,5T	√	
38		Paraquat	√	
39	Bacteria	Coliform	√	
40				
41	Oil & Surfactant	Oil & Grease	√	

Note: Water Quality Index is not applied in coastal water.
Source: JET

3.7 Step 5: Setting Time and Frequency of Monitoring

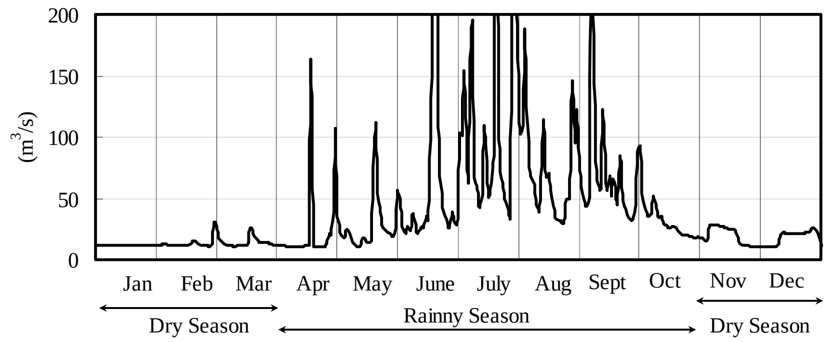
> According to Article 5.4, two guidelines are required as follows;
>
> a) Frequency of surface water monitoring is regulated as follows:
>
> - Frequency of baseline monitoring: at least one time per month;
> - Frequency of impact monitoring: at least one time per quarter.
>
> Based on the requirements of environmental management, monitoring objectives, characteristics of the water sources as well as economic and technical conditions, the frequency of monitoring will be determined appropriately.
>
> b) At the locations that are affected by the tidal regime or have a significant change of the nature and flow speed and direction, the frequency of surface water sampling shall be at least two times a day to ensure the overall assessment of the effects of the tidal regime.

As shown in the above box, the Article 5.4 requires frequency of surface water monitoring for baseline monitoring and impact monitoring. Besides, the article requires sampling times in brackish area affected by tidal regime. The handbook guides how to set timings of monitoring based on the required frequency and feature of water quality variation in the blackish area affected by tidal regime (See Section 6.4)

(1) Frequency of Surface Water Monitoring

1) River Water Flow Change in a Year

River water flow change is important information to set timing of monitoring. Figure 3.7-1 shows a river water flow change in Cau River, and shows the difference of stability of water flow between the dry season and the rainy season. Fluctuation of water flow affects water quality, so the record of water flow at exiting hydrological points shall be kept for analysis and evaluation of analytical results.

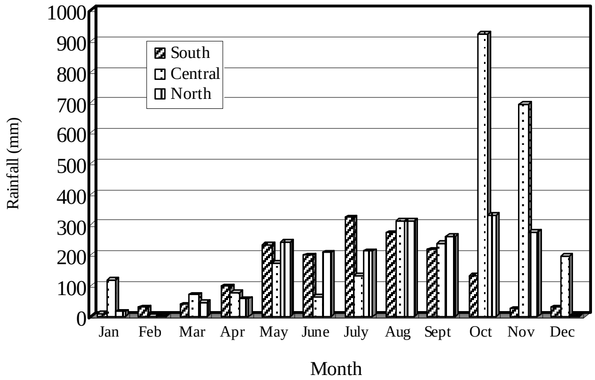


Source: Monitoring data by DWRM (2007)

Figure 3.7-1 River Flow in Cau River (Gia Bay Station)

2) Rainfall Pattern in a Year

Figure 3-6.2 shows the pattern of rainfall in Vietnam. This figure shows that pattern of rain fall is different in northern, central and southern part of the country. Timing of monitoring in the dry season and the rainy season should be set considering the difference of rainfall pattern in each area in Vietnam.



Source: Statistical yearbook of Vietnam 2007

Figure 3.6-2 Pattern of Rainfall in Vietnam

3) Water Usage Pattern

There are various types of water usages from river such as for hydropower, domestic, industry, irrigation. Especially water usage for irrigation significantly affects river follow in the downstream area of water intake point. For example, Table 3.7-1 shows amount of irrigation water usage from a weir and river flows before and after the weir. From November to March, the weir does not overflow since water from the river is regularly diverted to the irrigation canal. If some industries discharge wastewater complying with wastewater standard to the river directly in the downstream area of the weir, water quality shall be worse due to little amount of river flow from the weir. Thus timing of monitoring should be set considering water usage pattern.

Table 3.7-1 Irrigation Water Usage and River Flows at the Upstream and Downstream

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River flow at upstream of the weir (m^3/s)	12.3	12.6	12.4	12.5	49.3	90.7	162	154	105	38.7	20.9	14.5
Intake water for Irrigation (m^3/s)	12.3	12.6	12.4	12.5	20.2	28.5	20.2	20.2	20.2	24.2	20.9	14.5
River flow at downstream of the weir (m^3/s)	0	0	0	0	29.1	62.2	141.8	133.8	84.8	14.5	0	0

Source: JET

4) Setting Timing of Monitoring in a Year

Monitoring frequencies are set depending on DONREs' situations; budget, importance, human resources, equipment, and so on, According monitoring plans for 2012 in the target DONREs, they monitor river water quality 2 times/yr (HNI), 4 times/year (HUE), and 6 times/yr (HPG and BRVT), 12 times/yr (HCMC). Thus the handbook guides how to select timing of monitoring as shown in Table 3.7-2. As shown in Section 3.5, frequency of monitoring for some determinands, which complies with standard every time in a few years, could be reduced.

Table 3.7-2 Timing of Monitoring each Frequency

Frequency	Timing of Monitoring	Note
12 times per year	Every month	-
6 times per year	Every two months (Feb, Apr, Jun, Aug, Oct, Dec)	Monitoring in Jan, Mar, May, Jul, Sep, and Nov are also possible to present characteristic water quality changes in a year.
4 times per year	1st Quarter: Jan-Mar 2nd Quarter: Apr-Jun 3rd Quarter: Jul-Sep 4th Quarter: Oct-Dec	It is recommendable that timing of monitoring shall be set with consideration of rainfall pattern at least. Water usage pattern for irrigation shall be also considered if weir or dam exists upstream of monitoring points.
2 times per year	Dry Season Rainy Season	It is recommendable that timing of monitoring shall be set as representative month for dry and rainy seasons with consideration of rainfall pattern.

Source: JET

(2) Water Sampling in Brackish Area

Dynamic feature of water in brackish area is complicated because a lot of factors such as river flow, tidal level fluctuation, salinity, and river velocity are related each other. Left hand in Figure 3.7-3 shows three patterns of mixing river and sea water. Especially, little mixed case causes salt wedge and water quality in the surface and bottom are significantly different. Right hand in Figure 3.7-3 shows dynamic feature of suspended solid in brackish area. Resuspension of bottom sediment reaches to the surface water area after 2 hours from low tide water. Thus it is important to grasp mechanism of gravity current and dynamic feature of suspended solids when water sampling is carried out in blackish area.

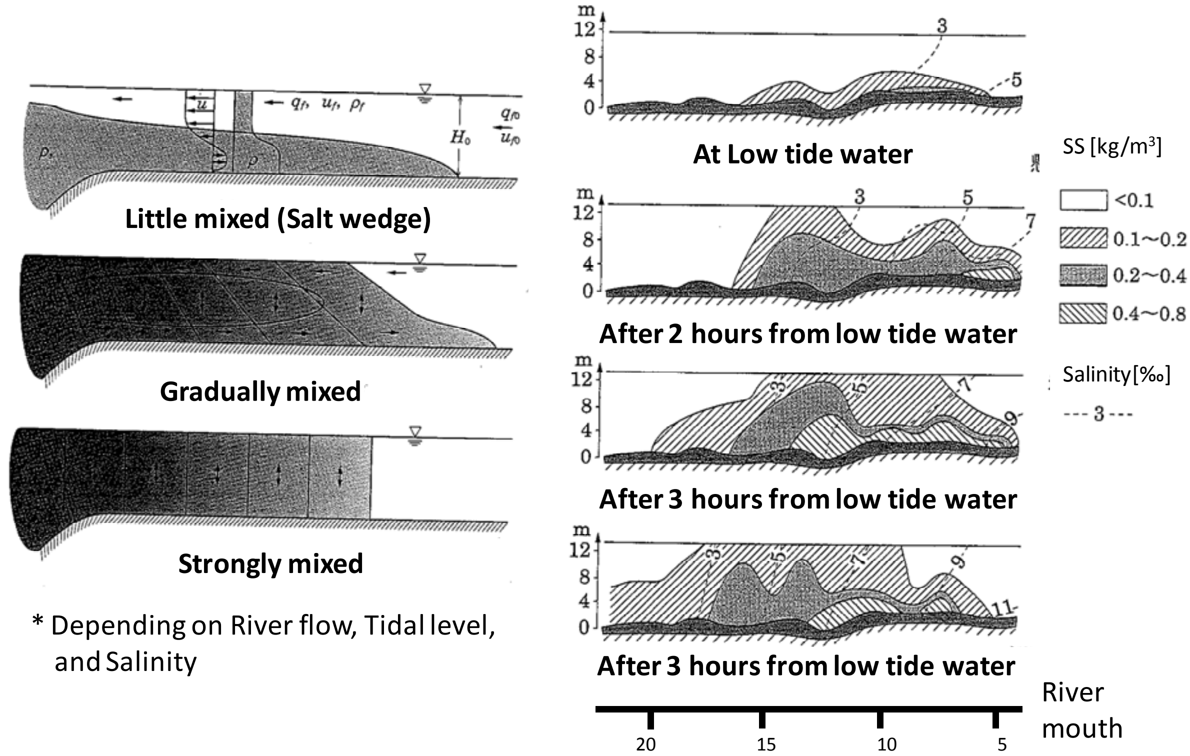


Figure 3.7-3 Mechanism of Gravity Current and Dynamic Feature of Suspended Solids in Brackish Water Area

3.8 Step 6: Planning for Monitoring

According to Article 5.5, Planning for monitoring is based on monitoring program, including the following contents:

a) List of staff carrying out the monitoring and assignment of the tasks to each staff involved;

b) List of organizations and individuals to coordinate implementation of environmental monitoring (if any);

c) List of equipment, tools, chemicals for monitoring in the field and laboratory analysis;

d) Protective facilities and equipment to ensure occupational safety while carrying out the environmental monitoring activities;

e) Types of samples to be taken, minimum sample volume and sample storage time;

f) Method of analysis in laboratory;

g) Funds for environmental monitoring;

h) Implementation plan for quality assurance and quality control in environmental monitoring.

As shown in the above box, seven items shall be included in the monitoring plan. Among seven items, four items are shown detailed guidance in some sections as shown in Table 3.8-1.

Table 3.8-1 Detailed Guidance of Planning for Monitoring

Requirement of the Circular	Detailed Description in the Handbook
List of equipment, tools, chemicals for monitoring in the field and laboratory analysis;	Section 4.1.1 Equipment for Field Survey Section 5.2 Instrumental Water Quality Analysis
Types of samples to be taken, sample volume and sample storage time	Section 4.1.2 Sample Containers Section 4.4 Sample Preservation, Transportation and Storage
Method of analysis in laboratory;	Section 5.1.1 Standard Method of Water Quality Analysis in Vietnam
Implementation plan for quality assurance and quality control in environmental monitoring.	Section 5.3.2 Quality Assurance (QA) and Quality Control (QC)

Source: JET

3.9 Step 7: Approval of Designed Monitoring Program

According to Article 5.0, monitoring program after being designed must be approved or consented to in writing by competent authority or by monitoring program management agency.

As shown in the above box, the article requires to get approval and consent by competent authority or by monitoring program management agency. As examples, HNI CENMA and HCMC CEMA need to get approval from DONREs, TT-HUE DONRE EPA and CEMAB in BRVT need to get approval from PPCs. On the other hands, HACEM in HPG can manage their monitoring plans by themselves within budget allocated from PPC and needs to report the outline of monitoring plan to PPC.

3.10 Reviewing Existing Monitoring Plan based on DQO Process Approach

3.10.1Introduction

In recent years there has been a move towards structured processes for the development of monitoring programmes that optimize the monitoring process. Such an approach provides a basis for the technical monitoring of the programme to determine whether it is meeting its objectives.

The most highly developed process is that known as the Data Quality Objectives (DQO) approach used by the US-EPA. The process is broadly divided into five steps as follows:

- Step-One: State the problem and what is known already about the problem
- Step-Two: Identify the question that the monitoring is to answer
- Step-Three: Identify the information required to answer the question
- Step- Four: Define the study area limits, spatial and temporal
- Step-Five: Define the statistical tests to be employed to answer the question and the actions to be carried out based on the answer to the question.

The full procedure for carrying out the process is given in detail in the US-EPA manual[1]. Taking into consideration the pre-project capacity and knowledge of the counterpart staff an attempt to develop the capability of the staff to carry out a **full** DQO based monitoring plan was thought to be overambitious within the time constraints of this project,.

A simplified approach, based on the DQO principles, was taken. This would develop the basic skills necessary to enable robust monitoring plans to be developed. These would act as a springboard for attempting more complex plans in the future. A pilot area was selected within the exiting monitoring program of each DONRE and each aspect of the program was reviewed taking into account the DQO principles.

During the training and workshop sessions the attendees were provided with hard copies of the training presentations that outlined the steps involved in the process and provided examples, how to

[1] Guidance for the Data Quality Objectives Process. EPA QA/G-4. EPA/600/R-96/055. United States Environmental Protection Agency. Office of Research and Development. Washington DC 20460. September 1994

assemble the information necessary for the development of the plan and how prepare a working for use in future monitoring programs.

The following sections of this chapter consider the main steps of the DQO process and show, by using examples from the training and workshops, how the steps were applied.

3.10.2The Basis of the DQO process.

The DQO process is a scientific method used to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that the data collection should satisfy. The aspects of monitoring covered includes:

- when to collect samples,
- where to collect samples,
- what to measure,
- how many samples to collect and
- tolerable level of decision errors for the study.

At this stage the capacity development focused on the first four and introduced the concept of the fifth. The DQO process can be applied to all types of water quality monitoring including effluent monitoring and receiving environment monitoring and is equally applicable to air quality and noise monitoring and the design of contaminated land investigations.

It is a planning tool that can save resources by making data collection operations more resource-effective. Good planning will streamline the study process and increase the likelihood of efficiently collecting appropriate and useful data. It provides a convenient way to document activities and decisions and to communicate the data collection design to others.

During the planning process the structured framework helps to focus studies by encouraging data users to clarify vague objectives and to limit the number of decisions that will be made.

Importantly, it enables data users, relevant technical experts and other stakeholders to participate in data collection planning and to specify their particular needs prior to data collection. It also provides a method for assessing decision performance requirements that are appropriate for the intended use of the data. This is done by considering the consequences of decision errors.

The first task is the description of the problem since this provides background information on the fundamental issue to be addressed by the monitoring. Based on a description of the conditions or circumstances that are causing the problem it is possible to describe the problem as it is currently understood by briefly summarizing existing information.

Based on the understanding of the problem the planning team is assembled. The team should include representatives from stakeholders in the project, and may include samplers, analysts and other scientists and engineers, modelers, technical project managers, community representatives, administrative and executive managers, QA/QC experts, data users, and decision makers. A reasonable effort should be made to include any decision makers who may use the study findings later. A statistician or someone knowledgeable and experienced with environmental statistical design and analysis should also be included.

The planning team should then work together to develop a conceptual model of the area in which the monitoring is to be carried out. The conceptual model should include:

- Basic hydraulic structure of the system, directions of flow, tidal regions, flow control and measurement structures
- Sources of pollution and pollution loads
- Locations of sensitive receivers, water intakes
- Basic land use categories.

At the same time, resources that are available for the monitoring should be identified together with the time boundaries that are relevant to the monitoring. This will include defining the anticipated budget and listing of available personnel and equipment that would be available, field and laboratory activity, in particular any commitment to other monitoring work. The time-frame for the monitoring is important, not only the final end date but also intermediate deadlines that may need to be met.

It is this point that the team should identify and agree the principal question for which the monitoring is to provide the answer. The question will be based on a review of the problem principal study question and should be stated as specifically as possible. Questions may be decision questions, the answer to which will led to a decision being made. Typical decision questions would include:

- Does the pollutant concentration exceed the QCVN for surface water quality?
- Is the effluent from the industry out of compliance with discharge limits?
- Is the contaminant concentration in the river below the city significantly different from that before the wastewater treatment plant was constructed?

If the question is a decision question the type of decision to be made is also considered. This will provide a guide when considering the consequences of making an incorrect decision.

Alternatively the question could be an informative question. Examples of informative questions are:

- What is the variation of concentration of a particular pollutant within the Province?
- How far inland does the tide affect salinity levels in the river?
- Does the concentration of a particular pollutant in the river differ between seasons?

Based on the conformation of the question to be answered the information that is needed to answer the question is listed. The list will normally include:

- locations of sensitive receivers
- specific water quality contaminants
- locations of industrial and municipal intakes and discharges
- rainfall
- river discharge

The next activity is to identify the sources of information required for both developing the monitoring plan and also to be collected during the monitoring to be able to answer the question or questions. These sources may include:

- results of previous water quality monitoring programs,
- data being collected by other departments or organizations
- regulatory standards
- published scientific reports
- collection of new data

Where collection of new data is involved all sampling methods proposed must ensure representative samples are taken from the environment without the sample being contaminated or the sampling process contaminating the environment.

Issues that need to be considered include:

- Ability to sample at different depths
- Sample volumes and the need to sample treatment on site
- Non-representative sampling in particular lateral and longitudinal non-homogeneity in rivers

Figure 3.10-1 shows the lateral separation between the main river flow and the flow from a tributary in the Saigon River. The extent of the flow separation would indicate that the bridge in the lower right-of-center of the picture is probably closest point to the confluence where good lateral mixing is achieved.

Figure 3.10-1 Lateral Separation of flows in the Saigon River.

Once the determinands to be measured and procedure for sampling has been established the next step is the selection of appropriate sampling and analysis methods. It is essential that an analyst or representative of the laboratory is involved at this stage of the planning. Issues that should be addressed include:

- Sample instability
- Possible contamination of samples between the time of sampling and analysis.
- Interferences and matrix effects in analysis
- Inability to determine the relevant forms of the determinand being measured
- Limits of detection, both those required to answer the questions and those that are achievable by the laboratory.

In order to be able to identify the locations at which samples should be taken the overall spatial boundary of the area to be monitored must be clearly identified. This should be drawn on a map together with any sub boundaries that may be required to establish areas in which different beneficial use categories are located and which may require different water quality standard to be applied.

The question to be answered may require further stratification to be applied to the geographical area, different physical conditions or river characteristics. Examples of stratification include:

- river hydraulic conditions
- time of year if there is marked seasonality
- time related to rainstorm event if the monitoring is addressing water quality affected by stormwater overflows
- sediment particle size if sediment is being analysed for presence of heavy metals or trace organic pollutants
- age or size of fish and type of tissue if contaminant accumulation in biota is being monitored.

The specification of size of sampling unit is a key factor in reducing the random variability associated with sampling. In this case ‘big is beautiful’ since the larger the sample, preferably created by combining a number of smaller samples, the more representative the sample becomes. In order to ensure consistency of random variation between successive sampling occasions the same size sampling unit should always be applied.

Any form of monitoring will be subject to practical constraints. These can be divided into internal and external constraints. Internal constraints can be categorized as:

- Staffing resources
- Equipment possession and availability
- Skills availability
- How the monitoring will be funded

External constrains will include:

- Physical access to the sampling sites
- Time of travel between sites and between the site and and the laboratory

Sampling will normally involve the collection of samples over time and/or space. It is necessary to define the statistic that will adequately describe the concentration over time or space and which be used in the decision process about the target population.

Commonly used statistics are:

Maximum:	The highest value in the data series. It is strongly influenced by a single extreme high value. It is appropriate when the concern about the pollutant being measured is its acute toxicity.
Minimum:	The lowest value in the data series but strongly influenced by a single extreme low value. Particularly valuable for dissolved oxygen.
Average:	The arithmetic mean is greatly influenced by extremes values and is not very useful if a large proportion (>50%) of values are below the detection limit. Appropriate for pollutants that give rise to chronic effects.
Median:	The median is not influenced by the extremes of the contaminant distribution and is a better estimate for a population that is highly skewed. Also it may be preferred if the population contains many values that are less than the measurement detection limit. The median is not a good choice if more than 50% of the population is less than the detection limit because a true median does not exist in this case.
Percentile:	Used where only a small portion of the sample concentrations can be allowed to exceed the Action Level. May require larger sample size than mean or median. Sometimes it is appropriate for pollutants that give rise to acute toxic effects. Useful when the data series contains values less than the detection limit.

Where the monitoring is being carried out to assist in a decision making process, an Action Level is required. There are two kinds of Action Levels. Those pre-determined and those determined within the monitoring process.

- Pre-determined Action Levels include fixed National Standards such as the QCVN for surface and ground waters.
- Determined Action Levels are more often used when monitoring construction when the concentration at impact sites are compared with variable background concentrations that are measured on the same day as the impact monitoring.

After determining the Action Levels the laboratory staff are then consulted regarding the limits of detection or limits of reporting that are achievable for each of the determinands in the monitoring program.

3.10.3Identification of Key Issues (Step 1 in DQO Process)

This session was for the groups to describe the key issues relating to surface water quality in their individual Province, to identify the threats to the quality of the water and consequences of deterioration of the quality. Attention was drawn to the problems with trans-Provincial boundary rivers and rivers which form boundaries between Provinces. Based on the description of the problem the groups then identified those stake-holders who would need to be consulted during the planning process, either as fully active participants or as providers of information to the planning team.

The groups were then introduced to a table which would be completed by adding the financial, human and technical resources which already existed and which were available for the execution of the monitoring plan. The timescale for the monitoring plan was defined in the table together with the timing of the issue for any contractual or regulatory reports relating to the results of the monitoring.

A conceptual model of the Province was then prepared identifying the hydraulic structure of the surface water network, including where appropriate the interface between it and the marine system. Figure 3.10-2 shows an example of conceptual model of the Sai Gon River in Ho Chi Minh City.

Pollution sources and sensitive receivers were identified together with basic land use categories and interfaces with adjacent Provinces. It was interesting to discover that where a river formed a boundary between two Provinces there frequently there was little or no interaction or resource and information sharing with the adjacent DONRE.

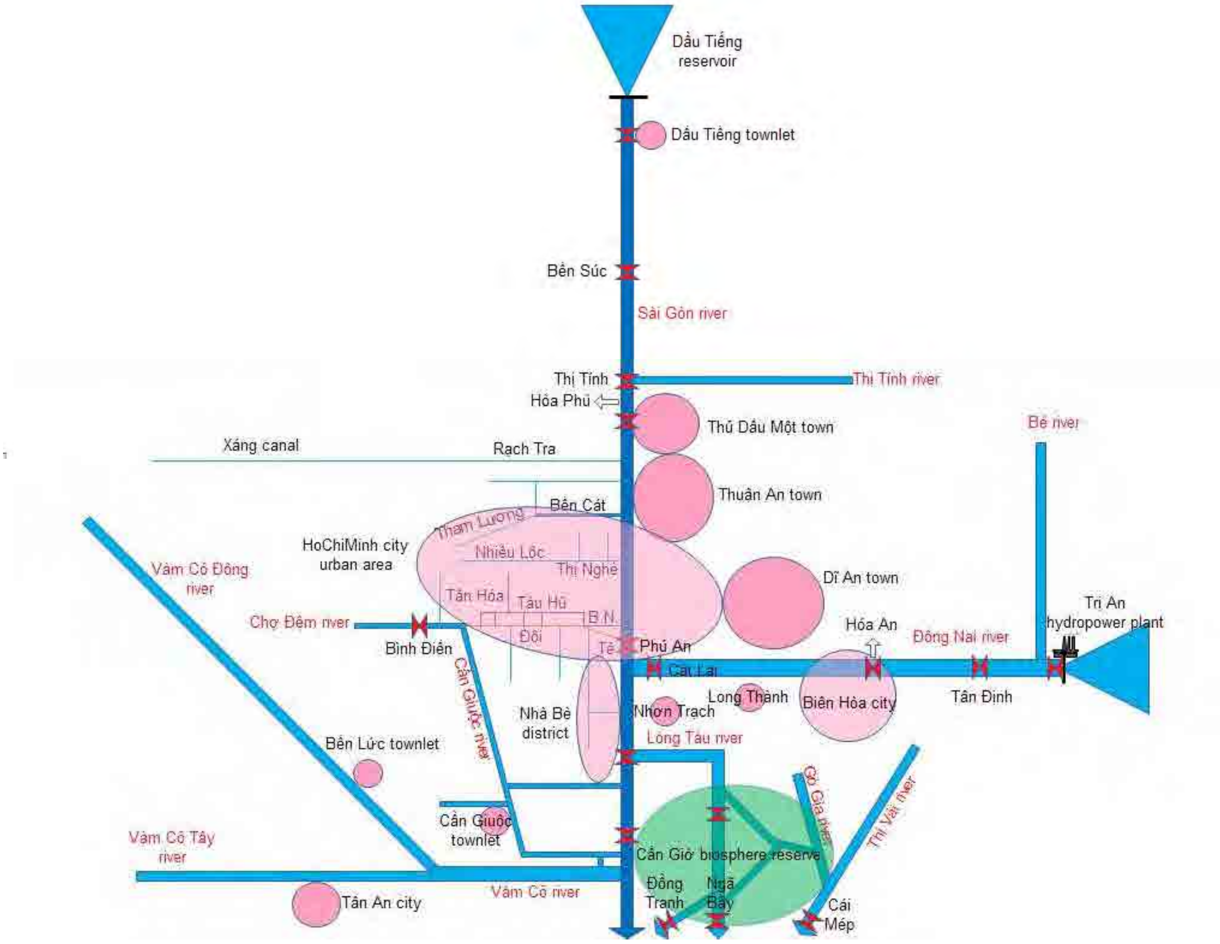
3.10.4Identification of the Objectives of the Monitoring Plan (Step 2 in DQO Process)

Based on the description of the problem and knowledge of the current monitoring plan, the objectives of the monitoring activity were defined. From the objectives of the plan a series of questions were constructed which the monitoring plan would be designed to answer. The purpose of the questions was to enable null and alternative hypotheses to be defined which could be evaluated statistically.

Where a DONRE would take actions directly as a result of the outcome of the monitoring, these would have been defined at this point. No DONRE actions would be triggered by the outcome of the monitoring program in any of the five DONRE undergoing training. In such cases the monitoring plan describes which body is responsible for taking any action that is required. This body would be included in the list of stakeholders.

In the Circular No.29 for regulation on surface water monitoring, fundamental objectives of surface water quality monitoring are;

1) To assess the current conditions of surface water quality in the region or locality,
2) To assess the suitability of the allowable standard for water environment,
3) To assess the changes in water quality over time and space,
4) To give early warnings of the consequences of water pollution, and
5) To follow other requirements of environmental management at national, regional, and local levels.



Source: JET

Figure 3.10-2 Conceptual Model in the Sai Gon River in HCMC

3.10.5 Identification of the Data and Information Required and how it will be Obtained (Step 3 in DQO Process)

Based on the conceptual model, the description of the objective and the questions to which the monitoring plan is designed to provide information, a series of tables were prepared containing a list of the information required to be able to answer the questions:

- The water quality determinands which are to be measured and the rational for their selection.
- Locations of pollution discharges, the type of industry/activity giving rise to the discharge, the principal contaminants in the effluent and the volume being discharged (these will eventually be imported from inventory database of pollution sources and the industry inspection database both of which are being developed under Outputs 2-3 and Output 2-4 of this project)
- Locations of water abstraction points on the river
- Location of other definable sensitive receivers
- Location of rainfall stations and river gauging stations.

The process then considered the type of sampling equipment which might be required by reference to the TCVN providing guidance on appropriate sampling methods for the different types of water body.

For each determinand to be measured the preservation procedure, the type of container to be used, the volume required and the maximum holding time are entered into the table. The information in the table is used to determine the total volume of water required for analysis and can be used to calculate the number and types of bottles required at each sampling station. The number of samples for each determinand and the maximum holding time can be used later by the analysts to program the analytical work load.

Finally the list is reviewed by the analytical staff to determine whether they have the capability to carry out analysis for all of the tabled determinands.

3.10.6 Definition of the Boundaries of the Monitoring (Step 4 in DQO Process)

This process defines specifically the nature of the samples to be collected and identifies the limits of the geographical area within which the data will be collected. This is an important step since it establishes the area within which the sampling stations are to be located. There may be sub-boundaries within the time and space boundaries of the monitoring area which need to be considered when placing sampling stations or establishing the timing of collecting samples. These include hydraulic conditions of the river, whether or not there are sections of the river that are influenced by tides, or whether there are likely to be differences in water quality between wet and dry seasons.

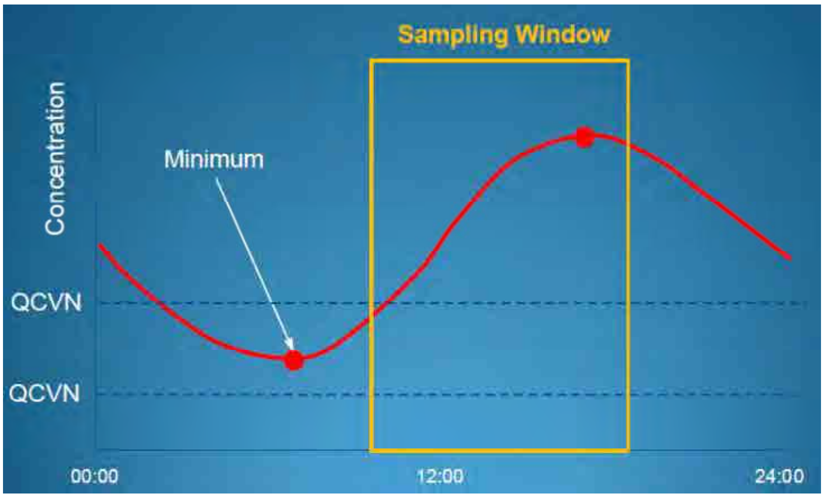
It is at this point that locations of monitoring locations are identified and tabulated. The locations take into account the boundaries described above and the following key factors:

- Known pollution sources
- Water abstraction points and other sensitive receivers
- River hydraulic behavior
- Accessibility and
- Any other local area specific issues.

The volume of water to be taken at beach sampling station is defined at this stage taking into account the volumes required by each determinand. The larger the volume of sample taken from the environment the more representative it is of the river. In order to standardize the ‘error’ around the sampling process the same volume must be taken on each occasion. A table that shows suggested container and minimum sample size of each determinand was presented at the training.

Temporal boundaries are defined. During the workshop some DONRE reported that their sampling teams did not travel to site on days when it was raining, resulting in samples taken only representing part of the year. If this is the case then the decision to stratify the sampling by ‘excluding’ rainy days must be recorded in the monitoring plan.

A problem common to all five DONRE and indeed most monitoring plans throughout the world is the effect of diurnal variation in water quality, particularly in lakes, but also in rivers exhibiting eutrophication, This is the fact that the dissolved oxygen concentration reaches its minimum, a value of high significance, occurs shortly before dawn. Most manual sampling takes place between 09:00hrs and 16:00hrs which excludes a highly significant part of the cycle. Figure 3.10-3 shows an image of diurnal variation in dissolved oxygen. Hence the minimum measured value and calculated annual average will tend to overestimate the true value. The monitoring plan must contain information regarding the time ‘window’ in which samples are collected.



Source: JET

Figure 3.10-3 Diurnal Variation in Dissolved Oxygen

Decision units were defined at this training where the groupings of adjacent stations with requirements for similar water quality are identified and the time scale over which the decision question is asked is identified. In most cases the time scale is a year since long-term water quality standards are expressed in terms of an annual value. Where bathing beaches are being monitored for the purpose of providing information relating to the microbiological quality of the water at the bathing beach it may be appropriate to adopt a much shorter time scale. In some cases, this is a matter of a few days.

It is also at this training that the requirements of the proposed plan were compared with the entries in the resource availability table prepared previously to identify and staffing, equipment or financial constraints which will require addressing.

3.10.7 The Analytic Approach (Step 5 in DQO Process)

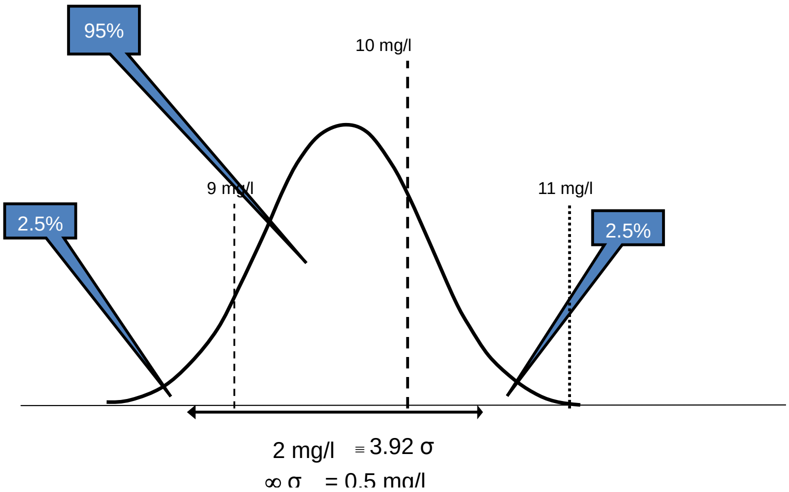
This training defined the statistical determinand which will used for each determinand and for each location the value of the test value, QCVN concentration, with which the determinands will be compared. These are entered into the determinand table. A Required Reporting Level (RRL) is entered in the table based on the values of the test value to be used. These values are discussed with the laboratory analysts to ascertain whether they can be achieved with their current analytical procedures. At this training it may be identified that the laboratory will need to adopt an analytical procedure which has an Actual Reporting Level (ARL) closer to the RRL.

3.10.8 Agreement of Decision Confidence Levels

Because of the combination of a large number of random variations associated with sampling in the field and the measurement of the concentration in the laboratory it is never possible to be 100% certain that the reported measured concentration is exactly the same as the true environmental concentration. For environmental studies it is common to accept a confidence level of 95%.

The planning process examines the consequences of requiring this level of confidence and the implications of the 5% of occasions when the true concentration is outside the range of confidence. Options of relaxing the confidence level to 90% and tightening it to 99% were examined. The consequences on adverse environmental impact or the financial cost of analyzing a large number of replicate samples were compared together with the possibility of reducing the magnitude of the combined random variability through modifying the design, improving sampling procedures or improving laboratory analysis.

Figure 3.10-3 shows example of estimation of standard deviation from % variation. The Student's t-value for a 2-tail test at 95% is 1.96. Therefore 95% of values lie within 1.96 standard deviations either side of the mean value. When carrying out a t-test on concentrations which are widely different, σ must be calculated at both of the concentrations and a t-test for unequal variances should be used.



.Source: JET

Figure 3.10-4 Example of Estimation of Standard Deviation from % Variation

3.10.9 Development of DQO Based Water Quality Monitoring Plan

Based on the five steps in DQO Process and agreement of decision confidence levels described in Section 3.10-1 to 3.10-8, target DONREs developed the draft revised monitoring plans of key rivers as the activities of the Project. Descriptions of the key river in each Province are shown in Table 3.10-1. The detailed contents of the draft monitoring plan of key rivers are shown in Appendix 1.

Table 3.10-1 Selected Key Rivers for Preparation of Draft Revised Monitoring Plan

DONRE	River	Reason for Selection
HNI	Red River	Red river is a major and important for not only HNI but also the North Vietnam being functioned water supply for agriculture and water navigation. Due to the fact that it is a trans-boundary and inter-provincial river, it is important to monitor the water quality of river before and after flowing through HNI city. The previous monitoring plan of Red river is just combined the plan in old HNI city with the plan in Ha Tay province in accordance with expansion of HNI city area in 2008. HNI CENMA needed to optimize the monitoring plan based on the two old monitoring plans. In this connection HNI DONRE selected Red river for preparation of draft revised monitoring plan.
HPG	Re River	Re river is the main river supplying drinking water for HPG city. Every year, Re river supplies roughly 45 million/m^3 of water for An Duong water plant, serving 80% of city's population. It also waters 10.000 ha of cultivated land in An Duong and Hong Bang districts. Recently from monitoring results, it is shown that the pollution is becoming more and more severe. Some pollutants such as Fe, TSS, NO_2, Phenol are always exceeding the QCVN 08:2008 level A2. Besides, other outputs (inventory, inspection, and environmental awareness) also focused on the Re river. In this connection HPG DONRE selected Re river for preparation of draft revised monitoring plan.
TT-HUE	Huong River	Huong river is the most important river in TT-HUE. There are a lot of water usages from upstream to downstream such as drinking water for approximately 300,000 residences in the center of HUE city, dams for hydro-power supply and flood control etc,, irrigation for vast area of cultivated land, and recreational activities by tourism boats. Besides, a new multi-purpose dam in the upstream of Huong River (Ta Trach River) has been constructed and will be completed in 2014. So, TT-HUE DONRE needed to revised monitoring plan of Huong river in accordance with construction of the dam. In this connection TT-HUE DONRE selected Huong river for preparation of draft revised monitoring plan.
HCMC	Sai Gon River	Saigon river is the main water supply source for HCMC supplying water for 68% of basin's population with the total volume of 330.000 m^3/day, subject to increase to 930.000m^3/day in 2020. It also waters not only for 12,000 ha of cultivated land in HCMC alone but also for water navigation and developing the aquaculture activities in the south of the city. However water quality in the upstream of water intake point has been declined due to wastewater from Industrial Zone in the other Provinces. So, HCMC DONRE needed to reconsider monitoring plan of Sai Gon river to check water quality for drinking usage. In this connection HCMC DONRE selected Sai Gon river for preparation of draft revised monitoring plan.
BRVT	Dinh River	Dinh river is the most important river in BRVT since the Da Den reservoir in the upstream supplies drinking water to approximately 400,000 residences in Ba Ria and Vung Tau cities. In addition, the downstream area of Dinh river (Cua Lap river) is also important for fishery, aqua-farming, and conservation of mangrove forest. However many mangrove areas have already changed to shrimp firms and water quality of the Cua Lap river is getting worse recently due to rapidly increase of waste and wastewater from seafood processing facilities, shrimp firming, and so on. In this connection BRVT DONRE selected Dinh river for preparation of draft revised monitoring plan.

Source: JET

(1) Monitoring Plan of Red River by HNI CENMA

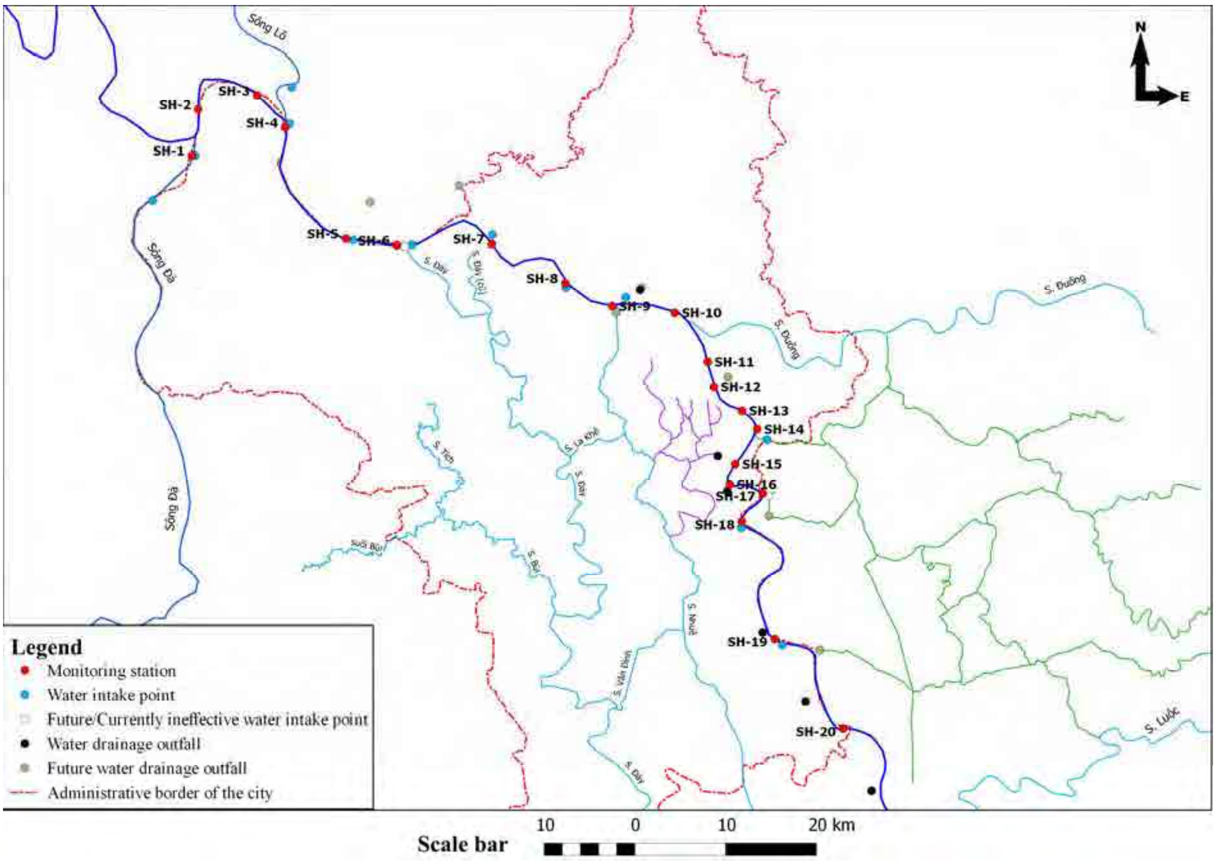
HNI CENMA developed a new monitoring plan in the Red River from first principles while drawing from the information available from the previous monitoring program with support of JET. CENMA drafted the revised monitoring plan of Red River for 2013 based on hydrological structure, water intake points, and distribution of pollution sources with support of JET.

The main change from the previous monitoring plan of Red River is the increase in monitoring frequency from 2-times/year to 4-times/year to meet the new circular on surface water quality monitoring (Circular No.29/2011/TT-BTNMT). On the other hand, the number of monitoring stations was reduced from 40 stations to 20 stations to offset the effect of the cost increase due to the doubling of monitoring frequency. The 20 monitoring stations were strategically positioned along the Red River in order to understand water quality variation of Red River. Table Table 3.10-2 shows the framework of the revised monitoring plan of Red River and Figure 3.10-5 shows the locations of the monitoring stations in the plan.

Table 3.10-2 Framework of Revised Monitoring Plan of Red River

Target River	Expected timing to start	Monitoring Plan in 2012	Draft Revised Monitoring Plan	Key Points for revising monitoring plan
Red River	From 2014	1) No. of Stations: 40 Stations 2) Frequency: 2 times/yr 3) Determinands 31 determinands; COD, BOD_5, DO, CN^-, NH_4^+, Cl^-, NO_3^-, NO_2^-, PO_4^{3-}, F^-, Oil & Grease, TSS, Total Phenol, As, Cu, Pb, Zn, Fe, Mn, Ni, Cr^{3+}, Cr^{6+}, Pesticide, Hg, Surface-active agent, Coliform	1) No. of Stations: 20 Stations 2) Frequency: 4 times/yr 3) Determinands 31 determinands (not changed); COD, BOD_5, DO, CN^-, NH_4^+, Cl^-, NO_3^-, NO_2^-, PO_4^{3-}, F^-, Oil & Grease, TSS, Total Phenol, As, Cu, Pb, Zn, Fe, Mn, Ni, Cr^{3+}, Cr^{6+}, Pesticide, Hg, Surface-active agent, Coliform	1) To increase monitoring frequency to meet with the circular on guideline of surface water quality monitoring (Circular No.29/2011/TT-BTNMT) 2) To relocate monitoring stations which can cover understanding water quality variation in comparison of monitoring plan in 2012

Source: CENMA and JET



Source: CENMA and JET

Figure 3.10-5 Location of Revised Monitoring Stations in Red River

(2) Monitoring Plan of Re River by HPG CEM (HACEM)

HPG CEM (HACEM) has already increased the number of monitoring stations of Re River from three to six stations within their existing budget since the 2011 monitoring plan. HACEM and JET held several discussion meetings about how to strengthen water quality monitoring of Re River for pollution control and for protection of drinking water resources. Table 3.10-3 shows the framework of the revised monitoring plan of Re River for 2013 and Figure 3.10-6 shows the locations of the monitoring stations in the plan.

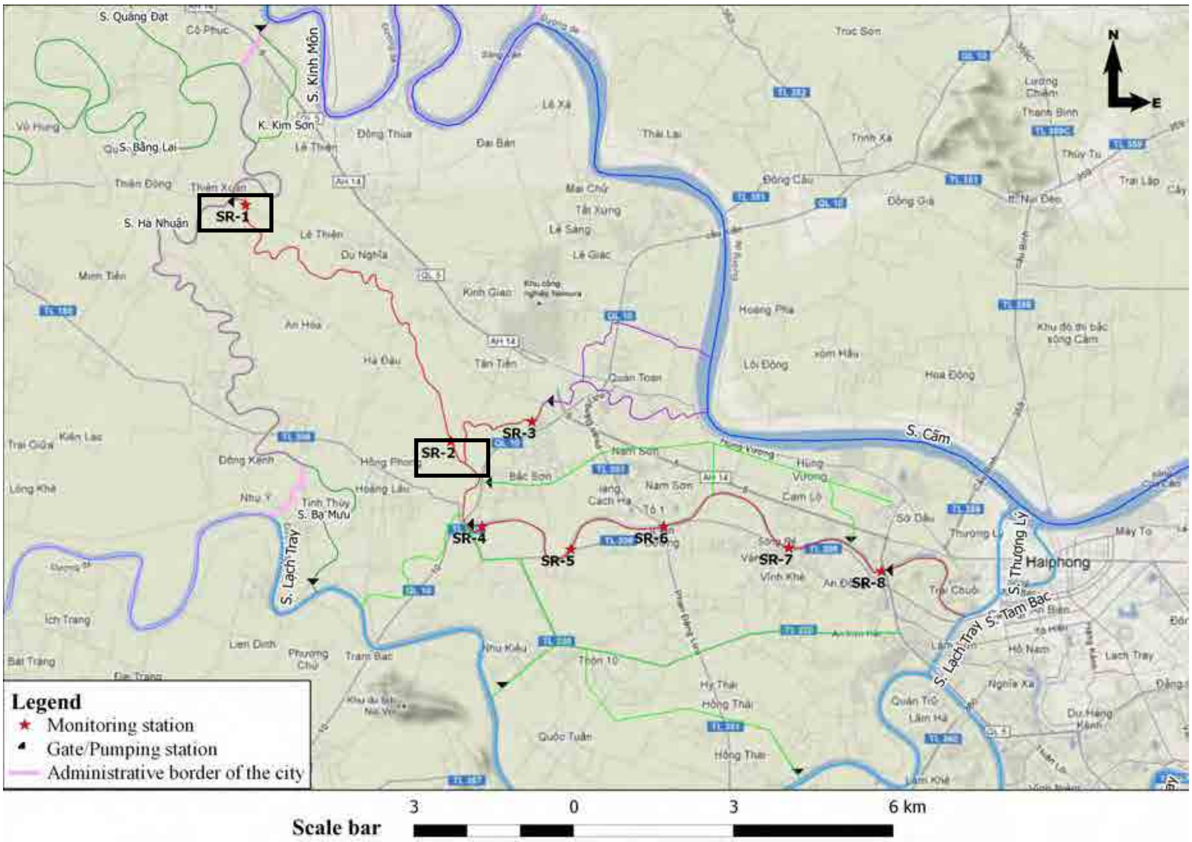
There are two main points in the revised plan for 2013.

- First, HACEM added two more monitoring stations; 1) at the most upstream of Re River (CT3 gate, SR-1) to check background water quality, and 2) at Sen gate (SR-2) to check impact from pollution sources located in Hong Phong and Bac Son Communes and water quality for irrigation use. Furthermore, if HACEM can get enough budgets, HACEM will add two more stations for the monitoring plan of Re River after 2013; 1) at the upstream of the An Duong Industrial Zone to be constructed for comparison of upstream and downstream water quality to check impact from the industrial zone and 2) at the end point of Bac Nam Hung Channel (An Tri gate) reaching Re River including wastewater from pollution sources.
- As for the second point, HACEM added two more determinands, turbidity and PO_4^-, to meet the requirement of the decision on calculation of water quality index (Decision 879/QD-TCMT). On the other hand, measurement of some heavy metal determinands at some stations, where compliance with the standard had been more than 80% in the previous 5 years, would be reduced from six times/year to one -three times/year to compensate for the budget increase due to increase of monitoring stations.

Table 3.10-3 Framework of Revised Monitoring Plan of Re River

Target River	Expected timing to start	Monitoring Plan in 2012	Draft Revised Monitoring Plan	Key Points for revising monitoring plan
Re River	From 2013	1) No. of Stations: 6 Stations 2) Frequency: 6 times/yr 3) Determinands 20 determinands; Temp., pH, turbidity, EC, odor, color, salinity, DO, TSS, BOD_5, COD, NO_3^-, NH_4^+, Zn, Cu, Cd, Pb, T-Coliform, oil and grease, total pesticides (Aldrin, Dieldrin, Endrin, DDT, Lindan)	1) No. of Stations: <u>8 Stations</u> 2) Frequency: 6 times/yr (not changed) 3) Determinands <u>22 determinands (Maximum);</u> Temp., pH, turbidity, EC, odor, color, salinity, DO, TSS, <u>Turbidity</u>, BOD_5, COD, NO_3^-, NH_4^+, <u>PO_4^-</u>, Zn, Cu, Cd, Pb, T-Coliform, oil and grease, total pesticides (Aldrin, Dieldrin, Endrin, DDT, Lindan)	1) To add to two more monitoring stations for strengthening pollution control and conservation of drinking water resources 2) To increase monitoring determinands to meet with the decision on calculation of water quality index (Decision 879/QD-TCMT)

Source: HACEM and JET



Source: HACEM and JET

Figure 3.10-6 Location of Revised Monitoring Stations in Re River

(3) Monitoring Plan of Huong River by TT-HUE DONRE EPA

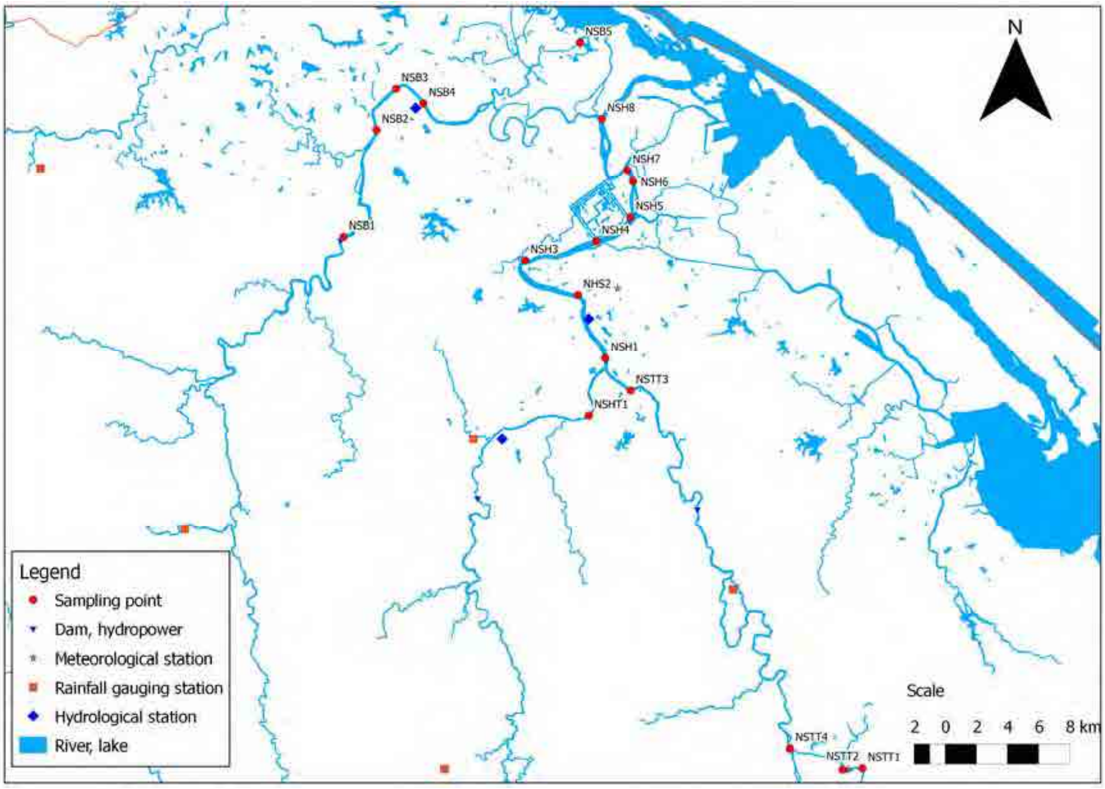
TT-HUE DONRE EPA and JET had several discussion meetings about how to strengthen water quality monitoring of Huong River especially for protection of drinking water resources. Table 3.10-4 shows a framework of monitoring plan of Huong River for 2013 and Figure 3.10-7 shows the locations of the monitoring stations in the draft plan. There are two main points of modification in the revised plan.

- As for the first point, EPA is going to add one two monitoring station; 1) at the downstream point of Ta Trach reservoir to check impact from construction activities and 2) at the downstream of Huu Trach River before confluence point with Ta Trach River to check impact of water pollution from Huu Trach River.
- As for the second point, the monitoring division added two more determinands, temperature and NH_4^+, to meet the requirement of the decision on calculation of water quality index (Decision 879/QD-TCMT).

Table 3.10-4 Framework of Draft Revised Monitoring Plan of Huong River

Target River	Expected timing to start	Monitoring Plan in 2012	Draft Revised Monitoring Plan	Key Points for revising monitoring plan
Huong River	From 2013	1) No. of Stations 10 Stations (Huong River) 6 Stations (Tributaries) 2) Frequency 4 times/yr 3) Determinands: 12 determinands; pH, DO, COD, BOD_5, TSS, Turbidity, NO_3^-, PO_4^{3-}, Cl^-, Fe, EC, Total Coliform	1) No. of Stations 11 Stations (Huong River) 8 Stations (Tributaries) 2) Frequency 4 times/yr (not changed) 3) Determinands: 14 determinands; Temp., pH, DO, COD, BOD_5, TSS, Turbidity, NH_4^+, NO_3^-, PO_4^{3-}, Cl^-, Fe, EC, Total Coliform	1) To add to two more monitoring stations for checking water pollution impact from tributary and reservoir construction 2) To increase monitoring determinands to meet with the decision on calculation of water quality index (Decision 879/QD-TCMT)

Source: EPA and JET



Source: EPA and JET

Figure 3.10-7 Location of Revised Monitoring Stations in Huong River and Its Tributaries

(4) Monitoring Plan of Sai Gon River by HCMC CEMA

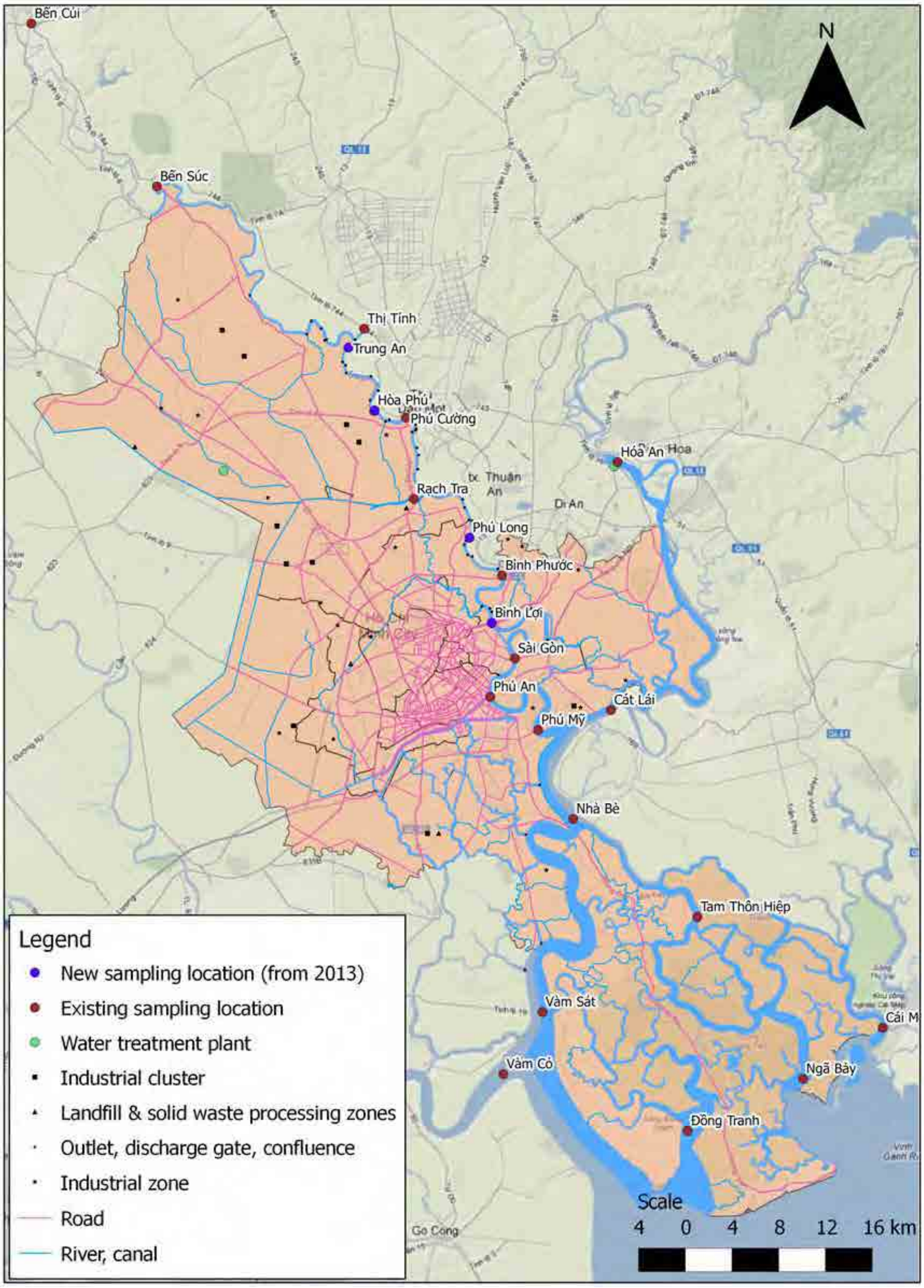
HCMC CEMA under HEPA has already increased the number of monitoring stations of Sai Gon River from 20 to 22 stations at the request from PPC to check before and after construction of new urban area. CEMA and JET had several discussion meetings about how to strengthen water quality monitoring of Sai Gon River for pollution control and protection of drinking water resources. Table 3.10-5 shows a framework of the draft monitoring plan of Sai Gon River for 2014 and Figure 3.10-8 shows the locations of the monitoring stations in the draft plan.

As the key point in the revised plan in 2014, CEMA added four more monitoring stations; 1) two stations at the upstream Hoa Phu water pumping station in Sai Gon River to check the impact from pollution sources in the upstream area and the water quality for domestic use and 2) one station to check impact from pollution sources from other provinces, and 3) one station to strengthen monitoring network to estimate possible water quality changes from upstream to downstream in the urban area of HCMC.

Table 3.10-5 Framework of Draft Revised Monitoring Plan of Sai Gon River

Target River	Expected timing to start	Monitoring Plan in 2012	Draft Revised Monitoring Plan	Key Points for revising monitoring plan
Sai Gon River	From 2014	1) No. of Stations: 22 Stations 2) Frequency 48 times /yr for basic determinands 12 times /yr for all determinands 3) Determinands 18 Determinands pH, Temp., Turbidity, Salinity, TSS, DO, BOD_5, COD, NH_4^+, PO_4^{3-}, E-coli, Coliform, Pb, Hg, Cd, Cu, Mn, Oil&grease	1) No. of Stations: 26 Stations 2) Frequency (not change) 48 times /yr for basic determinands 12 times /yr for all determinands 3) Determinands 18 Determinands (not change) pH, Temp., Turbidity, Salinity, TSS, DO, BOD_5, COD, NH_4^+, PO_4^{3-}, E-coli, Coliform, Pb, Hg, Cd, Cu, Mn, Oil&grease	1) To add to four more monitoring stations for strengthening pollution control and conservation of drinking water resources

Source: CEMA and JET



Source: CEMA and JET

Figure 3.10-8 Location of Revised Monitoring Stations in Sai Gon River

(5) Monitoring Plan of Dinh River by CEMA of BRVT (CEMAB)

Environmental monitoring plans until 2015 and during 2016-2020 in BRVT province have already been approved by BRVT PPC. In this connection, BRVT DONRE reviewed and prepared the draft revised monitoring plan in Dinh River after 2015.

CEMA of BRVT (CEMAB) and JET had several discussion meetings about how to strengthen water quality monitoring of Dinh River for protection of drinking water resources and for control of pollution especially from seafood processing. Table 3.10-6 shows a framework of monitoring plan of Dinh River after 2015 and Figure 3.10-5 shows the locations of the monitoring stations in the draft plan. To revise the plan, CEMAB conducted a four-day field survey in August 2012 by car and by boat to check hydrological structure, water intake points, and distribution of pollution sources, and to find appropriate sampling points to be added.

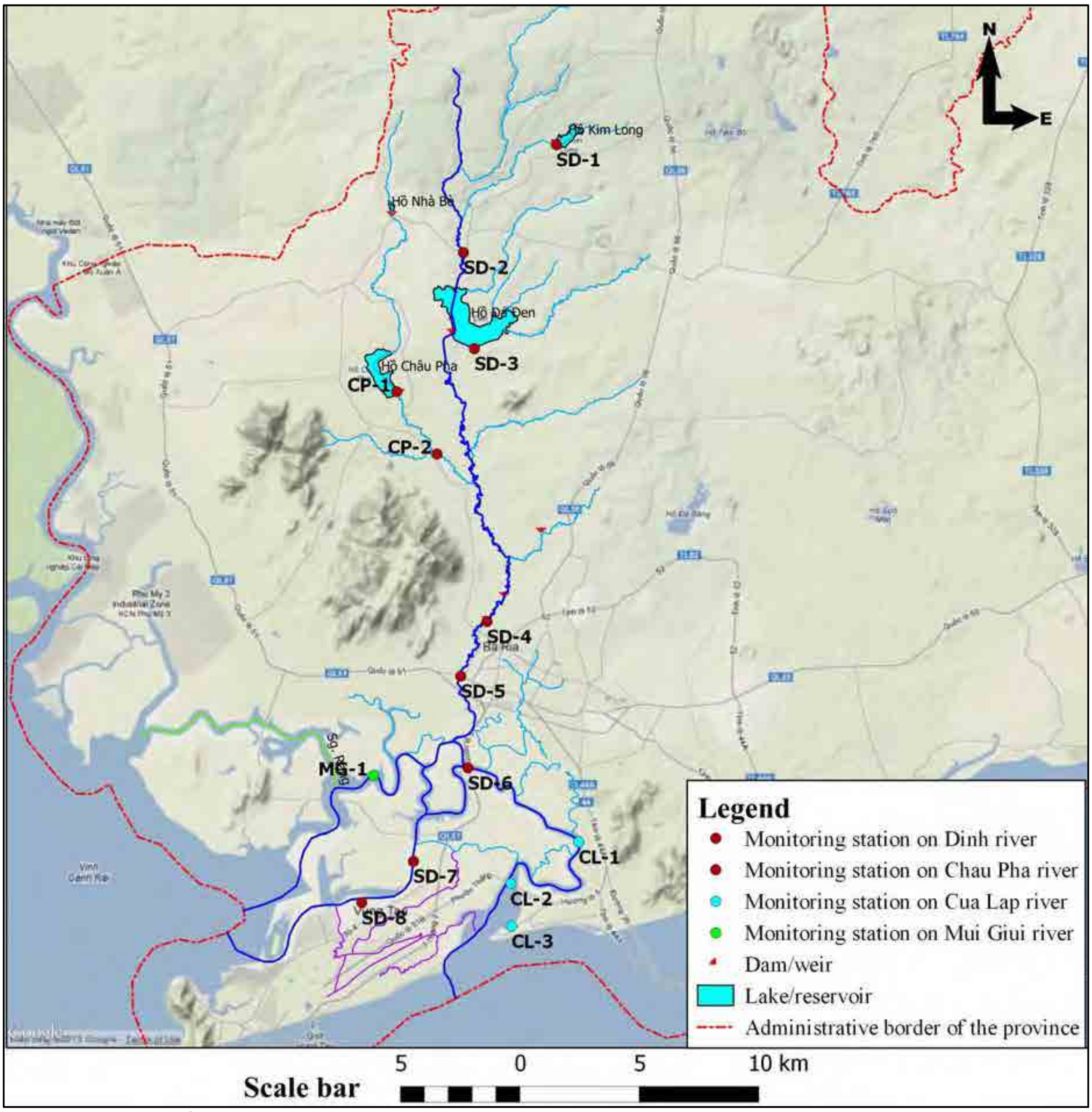
There are two main points in the revised plan for 2013 and beyond.

- First, CEMAB added three more monitoring stations; 1) at the downstream of Chan Pha reservoir to check impact from upstream area, 2) at the downstream of seafood processing factories zone to be constructed in Cua Lap River to check impact on water pollution from the factories, and 3) at the downstream Mui Giui River to check impact on water pollution from aqua-farming. If the budget allows, CEMAB will add two more stations for the monitoring plan of Re River from 2016; 1) at inlet of Da Den Reservoir to check water quality for domestic use impact and 2) at the downstream in Cua Lap River to check impact from small-medium scale seafood processing factories.
- Second, CEMAB is going to add two more determinands, temperature and turbidity, to meet the requirement of the decision on calculation of water quality index (Decision 879/QD-TCMT).

Table 3.10-6 Framework of Draft Revised Monitoring Plan of Dinh River

Target River	Expected timing to start	Monitoring Plan in 2012	Draft Revised Monitoring Plan	Key Points for revising monitoring plan
Dinh River	After 2015	1) No. of Stations 8 Stations (River and brackish area) 3 Stations (Lake) 2) Frequency: 4 times/yr 3) Determinands 12 determinands; pH, DO, SS, BOD_5, COD, PO_4^{3-}, NO_3^-, NO_2^-, NH_4^+, T-Fe, pesticides, Total-coliform (determinands are different from each monitoring station)	1) No. of Stations 11 Stations (River and brackish area) 3 Stations (Lake) 2) Frequency: 4 times/yr 3) Determinands <u>14 determinands</u>; <u>Temp.</u> pH, DO, SS, <u>Turbidity</u>, BOD_5, COD, PO_4^{3-}, NO_3^-, NO_2^-, NH_4^+, T-Fe, pesticides, Total-coliform (determinands are different from each monitoring station)	1) To add to three more monitoring station for checking impacts from pollution sources 2) To increase monitoring determinands to meet with the decision on calculation of water quality index (Decision 879/QD-TCMT)

Source: CEMAB and JET



Source: CEMAB and JET

Figure 3.10-5 Location of Revised Monitoring Stations in Dinh River Basin

CHAPTER 4 WATER SAMPLING AND ON-SITE MEASUREMENT

4.1 Preparation

Before going to the field survey, the following preparations need to be carried out:

- Prepare equipment for taking, holding, transporting and storing samples
- Prepare sample labels
- Prepare instruments for field measurements with calibration
- Prepare chemicals and tools for pretreatment on site to store water samples, and
- Prepare forms to record sampling and field measurement
- Check any necessary personal protection and safety equipment

4.1.1 Equipment for Field Survey

To measure water discharge of a river the following equipment is required (methods of measuring water discharge is shown in Section 4.3.3 in this handbook). On-site measurement instruments such as pH meter should be calibrated before going to the field survey (see Section 4.1.4). Basic equipment for field survey is listed in the following table.

Table 4.1-1 Sampling Equipment and Instruments

Investigation Item		Comment
Measuring water discharge	Current meter	Electromagnetic flow meter or Price current meter
	Stop watch	
	Measure tape	
	Plastic tape	
On-site measurement	Thermometer	
	pH meter	
	EC meter	
	DO meter	
	Distilled water	
	Field note, pen	
Sampling	Beaker with handle	Made of plastic
	Bucket	
	Rope	
	Dipper	
	Sample containers	Made of plastic, glass
	Name tag (seals)	For putting the name on the sampling bottle.
	Camera	
	White board and pen	
	Paper napkin	
	Scissors or Knife	
	Garbage bag or Plastic bag	
	Reagents	For preserving
Safety Equipment	Waterproof clothing	
	Buoyancy aid/life jacket	
	Rubber boots/waders/chest waders	
	Hard hat	
	First Aid Kit	
Transportation	Sample storage/ transit containers	It is necessary to cool the samples.
	Vehicle for field work	The vehicle which have sufficient capacity for personnel, supplies and equipment

Suitable sample containers should be selected depending on determinands to be measured (see Section 4.1.2).

4.1.2 Sample Containers

Normally, polyethylene or colorless glass bottles with ground stoppers are used as sample containers. Samples should not be contaminated and there should not be any losses of target components. So, a container must be made of a quality material and a cap should be closed properly. Before being used, it should be washed and rinsed carefully, and rubber and cork stoppers must not be used to avoid contamination of a sample.

An amber-colored bottle which blocks light should be used for samples containing components that are liable to photochemical or photolysis reactions such as agricultural chemicals, organic chemical components, and nitrite ions. The bottles should be wrapped with shade paper or put in a shade bag and placed in a cool box for transport to a laboratory. Measurements should be carried out as soon as possible in a laboratory.

The volume of sample water required differs depending on analytic methods and concentration of target components. The required volume for each determinand should be considered and determined beforehand (see Table 4.1-2).

Table 4.1-2 Suggested Container and Minimum Sample Size of each Determinands

P = Plastic (polyethylene or equivalent); G = Glass; G(A)or P(A)= rinsed with 1+1 HNO3;
G(B) = glass, borosilicate; G(S) = glass, rinsed with organic solvents or baked

Determinands			Container	Minimum Sample Size (ml)
1	Physical -chemical determinands	Water Temperature	P,G	
2		Color	P,G	500
3		Odor	G	500
4		Suspended solid	P,G	500-1000
5		Conductivity	P,G	100
6		Turbidity	P,G	100
7		Dissolved solid	P,G	200
8		pH	P,G	50
9		DO	G	100
10		Hardness	P,G	100
11	Nutrients	Ammonia	P,G	500
12		Nitrate	P,G	100
13		Nitrite	P,G	100
14		Total nitrogen	P,G	100
15		Phosphate	G(A)	100
16		Organic phosphorous	P,G	100
17		Total phosphorus	(Container should have been cleaned with 1:1 HCl and rinsed with Deionized water. Don't use commercial detergents containing phosphate for cleaning glassware used in phosphate analysis)	100
18	Organic pollutants	COD	P,G	100
19		BOD	P,G	1000
20	Inorganic substance	Sodium	P	100
21		Potassium	P	100
22		Calcium	P,G	100
23		Magnesium	P,G	100
24		Barium	P,G	100
25		Boron	P(PTFE) or quartz	100
26		SAR	P,G	300
27		Sulfate	P,G	100
28		Chloride	P,G	50
29		Iron	P(A),G(A)	100
30		Manganese	P(A),G(A)	100
31	Toxic determinands	Fluoride	P	100
32		Cyanide	P,G	500
33		Cadmium	P(A),G(A)	100
34		Lead		100
35		Chromium (VI)	P(A),G(A)	1000
36		Chromium (III)	P(A),G(A)	1000
37		Total Chromium	P(A),G(A)	1000

Determinands			Container	Minimum Sample Size (ml)
38		Mercury	P(A),G(A)	1000
39		Copper	P(A),G(A)	100 each determinand
40		Zinc		
41		Nickel		
42		Tin		
43		Selenium		
44		Arsenic		
45	Others	Oil and Hydrocarbons	G, wide-mouth calibrated (Washed with soap, rinsed with water, and finally rinsed with solvent to remove any residues)	1000
46		Phenol	P,G, PTFE-line cap	500
47		Pesticides	G(S), PTFE-line cap	1000
48		DDT	G	500
49		Surfactants	P,G	500
50		Fecal coliform	Sterilized bottle	100
51		Total coliform		
52		Herbicide	G	500

Source: Standard Methods for the Examination of Water and Wastewater 20thEdition, 1998, APHA/AWWA/WEF,
ISO 5667-3: 1985 Water quality – sampling – Guidance on the preservation and handling of samples

4.1.3 Sample Labels

Labels for water samples should be prepared before the field survey. Labels must contain following information:

- Code of monitoring station
- Determinands
- Chemical for preservation:
- Sampling date and time:

Example: A sample is taken at a station with code OOO. Monitoring determinand is COD and preserved by solution of H_2SO_4. Sampling date is as “25 October 2011 at 14:45”.

(code OOO)
COD (H_2SO_4)
25/10/2011
14:45

4.1.4 Calibration of Instruments at Laboratory

Before going to the field survey, instruments for measuring water quality on-site are to be calibrated in the laboratory. The basic procedures for the calibration are shown in the following table.

Table 4.1-3 Calibration of instrument for on-site survey

Determinand	Equipment needed	Procedure of Calibration
1. pH	-pH meter with electrode (probe) and thermometer, -Buffer solutions for calibrating the instrument, -Distilled water, and -Data sheet.	-Prepare the pH meter and probe for use. -Calibrate the pH meter using the manufacturer's instructions. -Complete the calibration and check the standard for this instrument. -Record the calibration reading.
2. Conductivity	-Conductivity meter, -Distilled water, and -Data sheet.	-Prepare the conductivity meter and probe for use. -Calibrate the conductivity meter according to the manufacturer's instructions and record the reading.
3. Air Temperature	-Thermometer, and -Data sheet.	-
4. Water Temperature	-Thermometer, and -Data sheet.	-
5.1 Dissolved Oxygen (DO meter)	-Dissolved Oxygen meter, -Distilled water, and -Data sheet.	-Prepare the DO meter and probe for use. -Calibrate the instrument according to the manufacturer's instructions. -Record the calibration.

Source: Homepage of CHEHALIS RIVER COUNCIL URL: http://www.crcwater.org/wqmanual.html

4.2 Water Sampling

4.2.1 Standards of Sampling Methods

Sampling needs to comply with one of following methods in Table 4.2-1. Methods referred to by international standards or others issued by ministry or sector, or internal methods to be used need an approval document issued by an agency in charge of the management of environmental monitoring.

Table 4.2-1 Sampling Methods

No.	*Types of samples*	*Code of standards, methods*
1	Samples of river and spring water	TCVN 5996-1995 ISO 5667-6:1990(E) APHA 1060 B
2	Samples of pond and lake water	TCVN 5994-1995 ISO 5667-4:1987
3	Guidance on sampling of waste water	TCVN 5999-1995 ISO 5667-10:1992
4	Samples of bio-microorganism analysis	ISO 19458
5	Sediment sample	TCVN 6663-15: 2004 ISO 5667-15:1999
6	Guidance to take samples as plankton	APHA - 10200

Source: Decision__/2007/QD-BTNMT Process and Procedures on Continental Surface Water

4.2.2 Sample Type

Generally there are two types of sample called "grab sample" and "composite sample". A grab sample is one collected at a particular time and place. It represents the condition of the water at the time of sampling. Grab samples must be collected carefully to make them as representative as possible of the water as a whole. Composite sample is a number of grab samples collected at define intervals of time over a fixed period and mixed. This sample presents the average characteristics of water flow over that particular period of time.

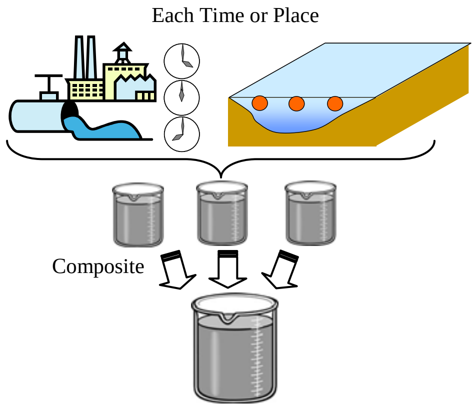


Figure 4.2-1 Image of Composite Sample

4.2.3 Selection of Sampling Point

Sampling points should be selected as follows.

- When the width of a river is narrow such as a branch stream, take a sample in the centroid of the river.
- When the width of a river is wide such as the main stream, take samples at a minimum of three points over the cross-section of a river. Mix them equally, then use the mixed sample as a representative sample of the sampling station. When this method of creating a composite sample is used, the same method and individual locations must be used each time. Any deviation from the specified procedure must be recorded in the field log.

4.2.4 Types of Water Sampler

Taking a sample directly to a container is the most desirable way to avoid contamination. However this is not usually the case because of the large volumes required and the specific requirements of the individual determinands to be measured. Multiple smaller volumes can be taken using, a handy instrument such as a bucket, dipper and so on. Such instruments made of polyethylene are often used. A rope can be attached to a bucket if necessary. Scoops with adjustable shafts (dipper) are convenient.

Samplers made of stainless steel can be used but they are not used in tests for tracing amount of heavy metals.

4.2.5 Procedure for Sampling

General procedures for sampling are as follows.

1) Rinse a sampling vessel with river water on site 2-3 times. Care must be taken to avoid contamination of target water during rinsing.
2) Scoop up some water at a sampling site; quickly rinse a sample container with water
3) Fill a sampling container with water and close it tight.
4) Take photograph with white board* during the sampling process.
5) After sample collection, fill out sample information forms.

Photo: Sampling and taking photograph

* Sampling station name, code, date, sampling implementing organization, and factory name, if necessary, are mentioned on the white board.

4.2.6 Quality Control (QC) Sample

In order to control quality during sampling, processing and preservation, QC samples (Field blank samples and Double field samples) should be used. QC samples should be taken at least once a sampling term. Section 4.3 provides more detail on the subject of QC.

4.3 On-Site Measurement

4.3.1 Measuring water quality on-site

On-site water quality measurement methods are shown in the following table. It is important to calibrate the equipment before field survey.

Table 4.3-1 On-site Water Quality Measurement Methods

Determinands	On-site
1. pH	- At each station, turn the meter on and place the probe into the water column. - Obtain the pH reading for each station. Wait until the meter reading stabilizes before reading and recording the pH and the temperature. - Record the pH on the data sheet. - Rinse the probe with distilled water. - Turn the pH meter off. Be careful to handle the probe carefully so as not to damage it while in the field. - If direct access to the water surface with the pH meter is not possible measure the pH in a sub-sample of the main sample. ON NO ACCOUNT measure directly in the main sample or return the sub-sample to the main sample container.
2. Conductivity	- Turn the conductivity meter on and place the probe into the water column and stir with the probe. - Wait until the meter stabilizes to obtain the reading for conductivity. The meter should be in the "Conductivity Mode". - Record the conductivity reading on the data sheet. - Rinse the probe with distilled water. - Turn off the conductivity meter and be careful when handling the meter and probe so as not to damage it while in the field.
3. Air Temperature	- Measure the air temperature by the stick shape thermometer.(at Good ventilation, 1.2-1.5 m height from the ground, Avoid direct sunlight). - Record the results recorded for temperature on the data sheet.
4. Water Temperature	- Insert a thermometer in sample immediately after sampling or insert a thermometer in water in the direct spot, and measure the water temperature - Record the results recorded for temperature on the data sheet. - Water temperature is required during data processing for temperature correction of pH, conductivity,

Determinands	On-site
	Dissolved oxygen saturation level and concentration of free Ammonia.
5. Dissolved Oxygen (DO meter)	- At each station, turn the meter on and place the probe into the water column and stir with the probe. - Adjust the salinity compensation switch to the measured salinity. - Allow sufficient time for the probe to stabilize before sampling the dissolved oxygen. - Record the readings for both concentration and percentage saturation. - Rinse the probe with distilled water. - Turn off the instrument and handle the probe carefully so as not to damage it while in the field.

Source: Homepage of CHEHALIS RIVER COUNCIL URL: http://www.crcwater.org/wqmanual.html

4.3.2 Field notes

The result of water quality measurement on-site is recorded as a field note. At least, the following information is to be mentioned on the field note.

- Sampling Date/ Time
- Sampling Location
- Result of water quality measurement
  (pH, Conductivity, Air temperature, Water temperature, DO)

Additionally, the following information is useful to evaluate the water quality data.

- Weather of sampling day or the day before sampling day
- Name of staff who take the sample
- If sampling at a bridge or other structure with a gauge board, record the level.
- Appearance of the river. Photograph anything unusual. (include location, date and time on a white board in the photograph)

4.3.3 Measuring water discharge

The river/stream flow or discharge is defined as the volume of water passing a single point in a river over time. It should be measured by determining a cross-sectional area and velocity (speed and direction) of the flowing water. The measurement is usually recorded in cubic meter per second (m^3/s). To calculate the pollution loads within a river basin, measurement of water discharge is very important. Because pollution load is defined as follows.

[Pollution load] = [Concentration] × [Water Discharge].

A section for discharge measurement does not need to be at exactly the same place as a sampling station, when there is no significant inflow or outflow between a water sampling station and water discharge measuring point. Bridges are preferred as river gauging stations because they usually allow easy access to full width of a river and a water level indicator can be fastened to a bridge pier or abutment.

To calculate the pollution load, a measurement of the water discharge is necessary. This manual proposes an estimation method to measure water discharge as following three steps.

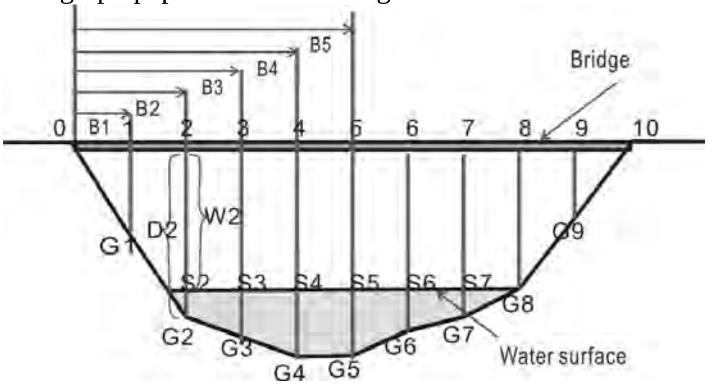
1) Measure Area of a cross section
2) Measure water velocity
3) Measure water discharge by bucket method in case of small effluent discharge channel

(1) Measure Area of Cross-section

The area can be measure by the following procedure. (see Figure 4.2 and 4.3)

1) Set reference point 0 on the edge of a bridge as shown in Figure 4.2.
2) Measure a horizontal distance of a bridge, and divide the distance into 10-20 sections.
3) Measure a horizontal distance B1, from reference point 0 to point 1.
4) Measure a vertical distance D1, from point 1 on a bridge to the ground, G1.

5) Measure a horizontal distance B2, from reference point 0 to point 2.
6) Measure a vertical distance D2, from point 2 on a bridge to the ground, G2.
7) Measure a vertical distance W1, from point 2 to water surface, S2, in case there is water surface.
8) Repeat steps 3, 4, 5, and10 at all vertical lines in one cross-section of a valley.
9) In case there is a water level indicator fastened to the bridge pier or abutment, the vertical distances should be measured on the point.
10) Put these data on the graph paper as shown in Figure 4.3-2.



D is a vertical distance from the bridge to the riverbed

W is a vertical distance from the bridge to the water surface

Figure 4.3-1 Cross Section of Stream Divided into Vertical Sections

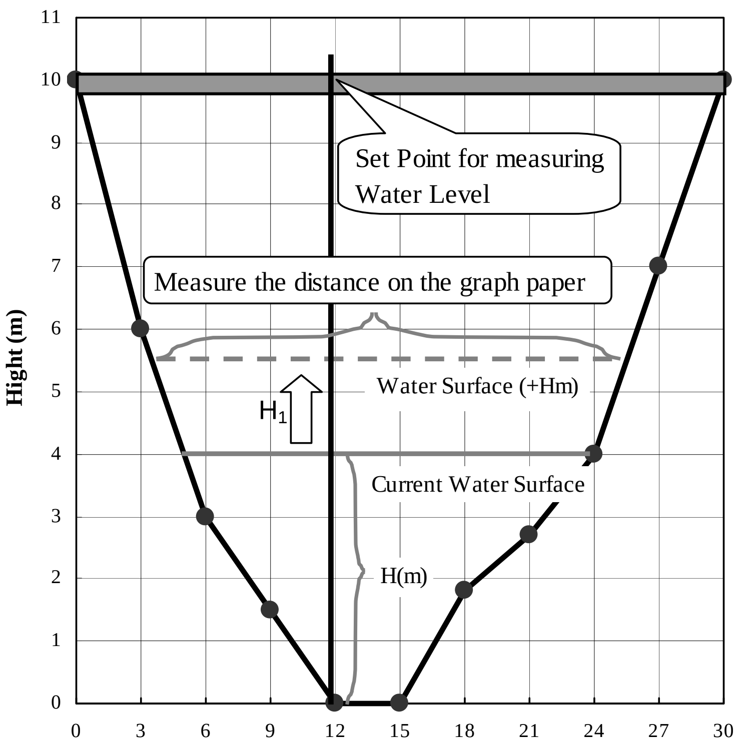


Photo: Measurement of Cross Section

Figure 4.3-2 Plotting the Figure of Cross-section on Graph Paper

The area of current cross-section is calculated as follows:

Area of the current cross section (A_T) $=A_2+A_3+\ldots+A_n$

$$A_2 = (D_2-W_2) \times (B_3-B_1)/2$$

• •

$$A_n = (D_n-W_n) \times (B_{n+1}-B_{n-1})/2$$

The method described above is appropriate for relatively small rivers where access can be gained from a bridge crossing the river. However in Vietnam there are many very wide rivers where access to anything other than the bankside is only possible by boat. In such cases the above procedure is not possible and an alternative procedure is required. Such procedures will be beyond the capabilities of most sampling teams or sub-contractors and a specialist survey company should be employed to carry out the measurements.

(2) Measurement of Velocity

A mean velocity can be measured at 60% depth from the surface in the centroid of a river.

On the other hand, the mean velocity can be estimated from measuring surface flow velocity. The basic idea is to measure the time that it takes the object to float a specified distance downstream. The mean velocity can then be obtained from measured surface flow velocity using a coefficient.

$$v_s = \frac{l}{t}$$

Where :

v_s = Surface velocity (m/s)
l = distance travelled (m)
t = time of travel (s)

and

$$v = kv_s$$

Where:

v = Mean velocity (m/s)
k = k is a coefficient (generally 0.8).
v_s = surface velocity

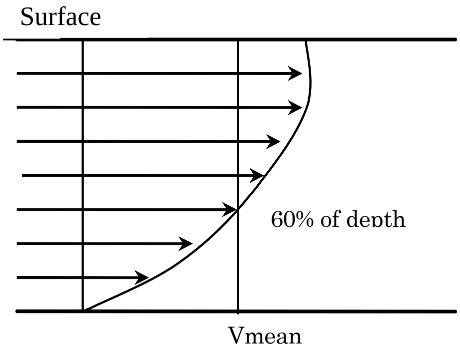


Figure 4.3-3 Velocity Distribution over Water Depth

The procedure for measuring velocity by the float method is as follows;

1) Choose a suitable straight reach with minimum turbulence
2) Mark the start and end point of your reach
3) Travel time should exceed 15 seconds.
4) Check an object (a piece of garbage or a branch on the surface of a river) flowing on the center of stream at upstream of your upstream marker.
5) Start the watch when the object crosses the upstream marker and stop the watch when it crosses the downstream marker.
6) Repeat the measurement at least three times and use the average in further calculations.

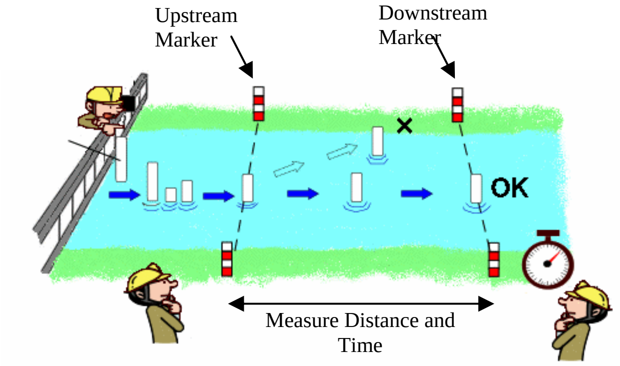


Figure 4.3-4 Float method for measuring surface velocity

7) Measure water level and calculate cross-sectional area.
8) Using corrected velocity and area of cross-section, discharge will be calculated.

$$Q = Av$$

Where:

Q = Discharge (m^3/s)
A = Area of cross section (m^2)
V = mean velocity (m/s)

When the width of a river is wide such as the main stream, you can divide the stream into 3 or more sections of float lanes, and measure surface velocities in each lane.

If the object floats high in the water, such as a polystyrene block or and empty plastic bottle, there is the possibility for the estimate of velocity to be affected by wind effects. Very suitable objects to observe are very ripe oranges since they float with only a small part of the fruit projecting put of the water and are of high visibility.

(3) Bucket Method

In case of measuring a water discharge of small channel or stream it is useful to use Bucket method. This method can only be used if the whole flow can be directed into the Bucket.

Procedure for Bucket method is shown as follows.

1) Collect an effluent with a bucket or a plastic bag,
2) Press a stop watch at the same time and measure the time till a bucket becomes full.
3) Repeat this several times and calculate the average and standard deviation.

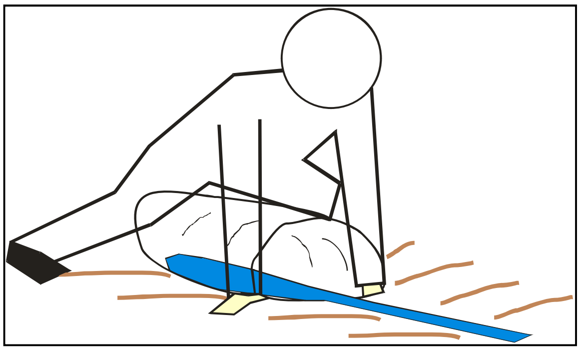


Figure 4.3-5 Bucket Method

$$Q = \frac{v}{t}$$

Where:

Q =Flow rate (m^3/sec)
V = volume of the bucket (m^3)
T =time taken to fill the bucket (sec)

(4) Estimation of River Discharge Using Discharge Observed at Other Sites

It is recommended to measure a river discharge at some of the water quality monitoring points. However, if it is difficult due to a low flow, etc., a river water discharge can be estimated using a river discharge observed at other points.

Inflow (water discharge or river confluence) and outflow (water usage for domestic, municipal, irrigation, and industry) of a river should be taken into account.

A river discharge at downstream Q_{down} can be estimated with a following equation:

$$Q_{down} = Q_{up} + \Delta Q_{in} - \Delta Q_{out}$$

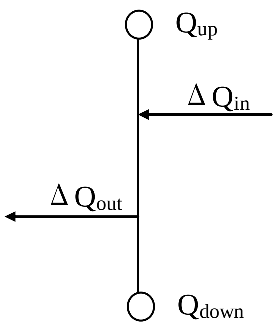


Figure 4.3-6 Schematic Diagram of Inflow and Outflow of River

4.4 Sample Preservation, Transportation, and Storage

4.4.1 Preservation

Recommended sample preservation treatments and maximum permissible storage times are as follows.

Table 4.4-1 Recommemded Preservation, Treatments, and Maximum Permissible Storage Times

Determinand			Preservation	Maximum Storage
1	Physical -chemical determinands	Water Temperature	Measure immediately	0.25 h
2		Colour	Refrigerate	48 h
3		Odour	Analyze as soon as possible; Refrigerate	6 h
4		Suspended solids	Refrigerate	7 d
5		Conductivity	Refrigerate	24h
6		Turbidity	Analyze same day; store in dark up to 24h, Refrigerate	24 h
7		Dissolved solids	Refrigerate	7 d
8		pH	Measure immediately	0.25 h
9		DO	Electrode: Measure immediately	0.25 h
10		Hardness	Add HNO_3 or H_2SO_4 to pH<2	6 months
11	Nutrients	Ammonia	Add H_2SO_4 to pH<3; Refrigerate	7 d
12		Nitrate	Refrigerate	48 h
13		Nitrite		48 h
14		Total nitrogen		48 h
15		Phosphate	For dissolved phosphate filter immediately (GF/C grade filter); Refrigerate	48 h
16		Organic phosphorous	Add H_2SO_4 to pH<2 and Refrigerate	28 d
17		Total phosphorus		28 d
18	Organic pollutants	COD	Analyze as soon as possible, or add H_2SO_4 to pH<2; Refrigerate	7 d
19		BOD	Refrigerate	6 h
20	Inorganic determinands	Sodium	Add acid to pH<2	1 month
21		Potassium	Add acid to pH<2	1 month
22		Calcium	Add acid to pH<2	1 month
23		Magnesium	Add acid to pH<2	1 month
24		Barium	Add acid to pH<2 (not use H2SO4)	1 month
25		Boron	HNO_3 to pH < 2	28 days
26		SAR	Add acid to pH<2	1 month
27		Sulfate	Refrigerate	28 d
28		Chloride	None required	28 d
29		Iron	For dissolved metals filter immediately; add HNO3 to pH <2	6 months
30		Manganese		
31	Toxic determinands	Fluoride	None required	28 d
32		Cyanide	Add NaOH to pH > 12, refrigerate in dark	24 h
33		Cadmium	For dissolved metals filter immediately; add HNO_3 to pH <2	6 months
34		Lead		
35		Chromium (VI)	Refrigerate	24h
36		Chromium (III)	Refrigerate	24h
37		Total Chromium	For dissolved metals filter immediately; add HNO_3 to pH <2	6 months
38		Mercury	Add NHO_3 to pH2, , refrigerate at 4 degree Celsius	28 days
39		Copper	For dissolved metals filter immediately; add HNO3 to pH <2	6 months
40		Zinc		
41		Nickel		
42		Tin		
43		Selenium		
44		Arsenic		
45	Others	Oil and Hydrocarbons	Add HCl or H_2SO_4 to pH < 2 Refrigerate (Don't overfill the sample container and don't subdivide the sample in the laboratory. Refrigerate)	28 days
46		Phenol	Refrigerate, add H_2SO_4 to pH < 2	28 days until

Determinand			Preservation	Maximum Storage
				extraction
47		Pesticides	Refrigerate, add 1000mg ascorbic acid/L if residual chlorine present	7 days
48		DDT	Refrigerate	24h
49		Surfactants	Refrigerate	24h
50		Facal coliform	Refrigerate	8h
51		Total coliform		
52		Herbicide	Refrigerate	24h

Source: Standard Methods for the Examination of Water and Wastewater 20thEdition, 1998, APHA/AWWA/WEF,

TCVN 5993:1995(ISO 5667-3: 1985) Water quality – sampling – Guidance on the preservation and handling of samples

4.4.2 Transportation

Samples should be transported in transit containers with appropriate packing to avoid bottle breakage. Effects of light and heat should be avoided because sample quality can be changed quickly due to chemical reaction, and uptake by micro-organisms. Water samples should be kept at around 4°C during transportation.

Photo: Sample Transportation with Refrigerant or Ice

Handover of water samples from one party to another party should be carried out in the field (a field group giving them to a transporter) or in a laboratory (a field group or sample receiver giving it to a laboratory).

Handover of samples should be recorded on a Chain of Custody form with full signature of relevant parties together with date and time. The record includes contents shown in the following table.

Table 4.4-2 Record Format for Delivering Water Samples

No	*Sampling date*	*Name of sampling station*	*Number of samples*	*Handed over by*	*Received by*	*Time of Exchange*
				Name of sample giver	*Name of sample receiver*	

4.4.3 Storage

A guideline for sampling transportation, stability, and preservation is presented in ISO 5667-3 and APHA.

Photo: Sample Storage

Appropriate actions should be taken to preserve samples immediately after sampling. Generally, a sample should be refrigerated, treated by chemicals, or its pH should be controlled for preservation of target determinands depending on a test procedure for each determinand.

As a general rule, a collected sample must be stored in accordance with a specific method for each determinand. Suggested preservative treatment and maximum permissible storage time are listed in Table 4.6. For determinands other than those in Table 4.6, samples should generally be stored under a dark and cool condition (around 4°C).

CHAPTER 5 WATER QUALITY ANALYSIS AND QA/QC

5.1 Basic Water Quality Analysis

5.1.1 Standard Method of Water Quality Analysis in Vietnam

Water quality analysis methods were standardized in Vietnam as shown in Table 5.1-1. Water quality measurement should comply with the following methods. Other methods from international standards can be used, but they should be checked and validated using standard solutions and a record kept of the results of the check and validation. Sample Standard Operating Procedures of basic water quality analysis are attached on the handbook.

Table 5.1-1 Analysis methods used in laboratories

Determinand			Code of standards and methods
1	Physical -chemical determinands	Water Temperature	TCVN 4557 – 88
2		Colour	TCVN 6185 : 1996; ISO 7887 : 1985
3		Odour	ISO 7887-85 (E); APHA2150 B
4		Suspended solids	TCVN 4560-1988; ISO 11923; APHA-2540D.
5		Conductivity	measured by electrical conductance meter
6		Turbidity	TCVN 6184-1996; APHA-2130 B
7		Dissolved solid	TCVN 4560:1988; APHA 2540 C
8		pH	TCVN 4559-1998; TCVN 6492:1999; APHA 4500-H^+B.
9		DO	TCVN 5499-1995 ; ISO 5814 – 1990; ISO 5813 ; APHA 4500
10		Hardness	TCVN 6224 : 1996;(ISO 6059 : 1984)
11	Nutrients	Ammonia	TCVN 5988-1995. ; APHA-4500.
12		Nitrate	TCVN 6180: 1996. ; ISO-10340-1:1992. ; APHA-4500 NO3- E .
13		Nitrite	TCVN 6178-1996. ; ISO-10340-1:1992.
14		Total nitrogen	TCVN 6624-1: 2000; ISO 11905-1: 1997
15		Phosphate	TCVN 6202-1996. ; APHA-4500P E .
16		Organic phosphorous	ISO 6878-1:96
17		Total phosphorus	APHA - 4500P(B, E)-1995, hach 8190-1998
18	Organic pollutants	COD	TCVN 6491 - 1999. ; APHA-5220
19		BOD	TCVN 6001-1995. ; APHA-5210 B
20	Inorganic substance	Sodium	TCVN 6196 -1-1996 ; TCVN 6196 - 2 -1996; APHA -Na/K; ISO 9964-1
21		Potassium	TCVN 6196 -1-1996 ; TCVN 6196 - 2 -1996; APHA -Na/K; ISO 9964-1
22		Calcium	TCVN 6196 -1-1996 ; TCVN 6196 - 2 -1996; APHA -Ca/Mg
23		Magnesium	TCVN 6196 -1-1996 ; TCVN 6196 - 2 -1996; APHA -Ca/Mg
24		Barium	AOAC 920.201, APHA 3114
25		Boron	TCVN 6635: 2000; ISO 9390: 1990
26		SAR	Can be calculated from Na, Ca, Mg concentrations
27		Sulphate	TCVN 6200-1996. ; APHA 4500 - SO4-2 E, ; ISO 10340-1:1992.
28		Chloride	TCVN 6194-1-1996. ; ISO 10340-1:1992.
29		Iron	TCVN 6177: 1996; ISO 6332 ; APHA 3500-Fe
30		Manganese	TCVN 6002-1995; APHA 3500-Mn
31	Toxic determinands	Fluoride	TCVN 6490 : 1999; ISO 10359-2: 1994
32		Cyanide	TCVN 6181 -1996 ; ISO 6703-1
33		Cadmium	TCVN 6197:1996; EPA 6010B, ISO 8288; ISO 5961; APHA 3500 - Cd
34		Lead	TCVN 6193:1996; EPA 6010B, ISO 8288; APHA 3500 - Pb
35		Chromium (VI)	TCVN 6658: 2000; ISO 11083: 1994
36		Chromium (III)	TCVN 6658: 2000; ISO 11083: 1994
37		Total Chromium	TCVN 6224 - 1996; ISO 6059 : 1984
38		Mercury	TCVN 5990:1995; EPA7470A; EPA 6010B; ISO 17852; APHA 3500-Hg
39		Copper	TCVN 6193:1996; EPA 6010B, ISO 8288; APHA 3500 - Cu
40		Zinc	TCVN 6193:1996; EPA 6010B, ISO 8288; APHA 3500 - Zn
41		Nickel	TCVN 6193: 1996; ISO 8288: 1986

Determinand			Code of standards and methods
42		Tin	APHA 3500-Sn
43		Selenium	TCVN 6183: 1996; ISO 9965: 1993, ANPHA 3114; USEPA 7740
44		Arsenic	TCVN 6626:2000; ISO 11969:1996; EPA 6010B; AP HA 3500-As
45	Others	Oil and Hydrocarbons	TCVN 5070-1995; ISO-11046-1994 ; APHA 5520
46		Phenol	TCVN 6216-1996; ISO 6439; APHA 5530
47		Pesticides	EPA 508; EPA 630; EPA 614. TCVN 2740-86; TCVN 2741-86; TCVN 2742-86; TCVN 4541-88 ; TCVN 4542-88
48		DDT	AOAC 992.14; AOAC 990.06 and AOAC 991.07; ASTM D 3086 – 95 and EPA 507
49		Surfactants	TCVN 6622-1: 2000 (ISO 7875/1: 1984)
50		Faecal Coliform	TCVN 6189--2: 1996 (ISO 7899/2: 1984; NFT 90-416
51		Total Coliform	TCVN 6187-1-1996; TCVN 6187-2-1996; APHA 9221; APHA 9222
52		Herbicide	TCVN 3711-82; TCVN 3712-82; TCVN 3713-82

Source: Decision__/2007/QD-BTNMT Process and Procedures on Continental Surface Water
Decision No.117/2000/QD-BKHCNMT

5.2 Instrumental Water Quality Measurements

5.2.1 Overview

There are many instruments used for water quality measurements. We can obtain proper, reliable data only by using instruments correctly. To do so, it is important to

- Understand their operation
- Maintain equipment periodically
- Record information on the measurements or events

Of course, it is also important to make sure any pre-treatment before carrying out measurements using instruments is carried out properly. In Vietnam, most of laboratories in DONRE have already obtained VILAS accreditation equivalent to ISO 17025. In principle, therefore, instrument management is being operated based on the concepts of VILAS.

5.2.2 Types of instruments

Various kinds of instrument are used in the water quality measurements as shown in Table 5.2-1.

Table 5.2-1 Instruments used in water quality analysis

Type of instruments	Target analysis
Potentiometer	pH, fluoride, ammonium, other ions
Voltammeter	DO, anions
Conductivity meter	conductivity
Ultraviolet-visible spectrophotometer (UV-Vis)	ammonium, chloride, cyanide, fluoride, nitrate, nitrite, total nitrogen, phenol, phosphate, sulfide, arsenic, chromium, surfactants, COD, iron, manganese, total phosphor
Atomic adsorption spectrophotometer (AAS)	Mercury, arsenic, manganese, cobalt, iron, nickel, copper, zinc, cadmium, lead, chromium
Ion chromatograph (IC)	Fluoride, chloride, bromide, nitrate, nitrite, phosphate, sulfate, other anions
Gas chromatograph (GC)	chlorinated pesticides, phosphorous pesticides, phenol, VOCs
Gas chromatograph/mass spectrometer (GC/MS)	ultra-trace organic pollutants
High performance liquid chromatography (HPLC)	PAHs

5.2.3 Procedures to maintain performance

(1) Proper operation

To obtain reliable data using an instrument, initially it is necessary to understand clearly the operating procedures by carrying out the actions below.

- Confirm the procedures of the instrument to be used comply with those described in the approved analytical method to be used
- Read operating manual
- Prepare a flow chart of the procedures and any special actions in the common notebook and prepare an appropriate SOP.

In the first analysis,

- Establish calibration curves
- Try all the procedures using samples of known concentrations of the target determinand.

If any analytical conditions need to be changed,

- Validate any modified conditions or procedures using standards or the known sample to determine whether they are applicable to the required analytical method or not
- If applicable, change conditions or procedures in the respective analytical SOP

(2) Proper maintenance

<u>Planned maintenance</u>

It is necessary to keep instruments in good condition. Recommended maintenance is usually described in the instrument maintenance manual. In general, planned maintenance is usually distinguished by its being scheduled daily, weekly, monthly or yearly maintenance. Extensive monthly or yearly maintenance is frequently carried out by an engineer under a contract with the manufacturer engineer. Every maintenance should be recorded in log books. This is particularly important during the warranty period of the instrument in the event that a claim has to be made to the manufacturer.

Table 5.2-2 Examples of maintenance [a)]

Maintenance period	Examples of maintenance
Daily	Cleaning of cell, cleaning of the body of instrument
Weekly	Cleaning around plug or outlet,
Monthly	Cleaning of reaction vessel, cleaning of injector, cleaning of fan, exchange consumables, calibration
Yearly	Exchange of lamp, exchange of filter, cleaning of detector, exchange consumables
Bi-yearly	Exchange of detector

a) Adequate maintenance period is dependent on instrument and the state of the use.

<u>Unplanned maintenance</u>

The procedures should make provision for unexpected problems. The procedure should define who has responsibility for the instrument, names of in-house staff who have been trained to carry out basic maintenance and who is responsible for contacting the manufacturer’s service engineer, etc.

<u>Recording</u>

To ensure the adequate functioning and performance of instruments, it is necessary to record or to make documentation daily and any time at maintenance.

- The individual analysts shall record in the instrument specific log book every time and for how long the instrument in use
- The instrument owner (responsible person) shall enter planned and unplanned maintenance activities in the maintenance log using the predetermined format
- For unplanned maintenance, the instrument owner also documents the reason for the maintenance problem and how the problem was solved
- The log sheets shall be maintained in binder close to the instrument

5.3 Laboratory Management and QA/QC

5.3.1 Laboratory Management

Laboratory management can be categorized into four types of management as follows.

Management of
- Laboratory,
- Equipment,
- Chemicals, and
- Waste Water

(1) Management of Laboratory

When a DONRE plans to develop a laboratory, it is necessary to consider the design of laboratory at the beginning stage. A procedure for designing a laboratory is show below.

a) Identify the types of the room

Typical types of laboratory rooms are listed in the figure below.

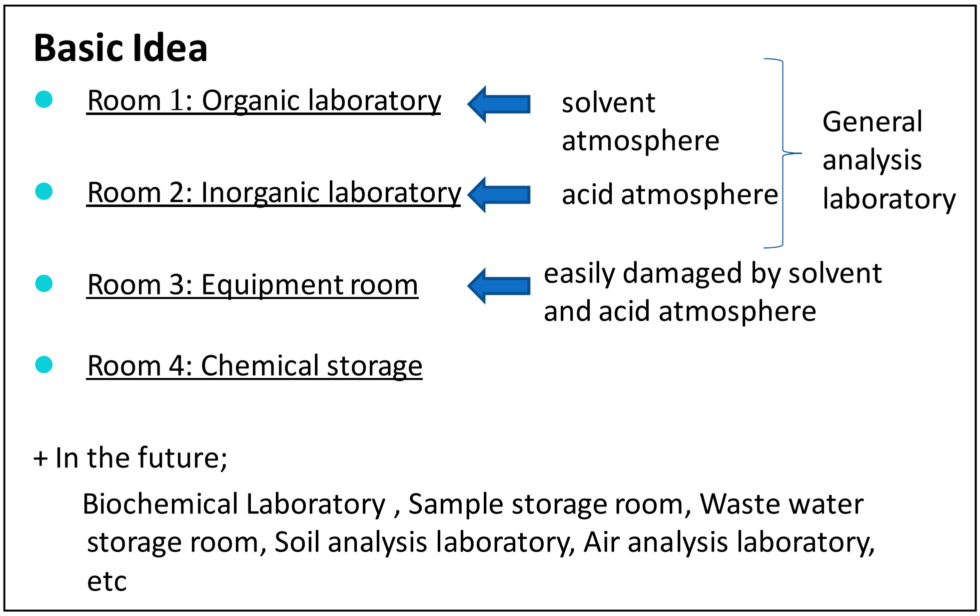


Figure 5.3-1 Typical types of laboratory room

<u>Services for the laboratory</u>

Analysis rooms need the following services.

a) Electricity; an additional 20 to 40% capacity of electricity is recommendable.

b) Water Supply, Drain (at least 2)

Water is used in a laboratory by several ways. (Washing Glassware and Equipment, Preparing pure water, Cooling condenser, and Emergency shower)

c) Sink for washing glassware

A wide sink is recommended to permit washing of long glassware such as a burettes.

d) Ventilation

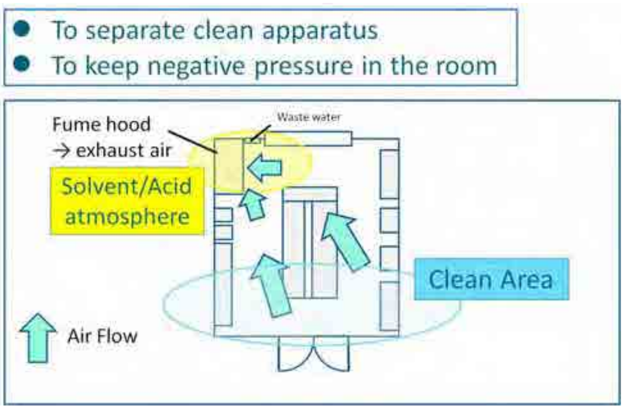


Figure 5.3-2 Ventilation system in laboratory

When office and laboratory spaces are connected, the airflow should enter via office spaces, and exit via hoods or other exhausts in the laboratory spaces

e) Air Conditioning

Air Conditioning is necessary for laboratories in Vietnam. In addition, dehumidifiers are also necessary for equipment which requires a dry atmosphere condition.

f) Work desk

Working desk must be stable, horizontal and have resistance against chemicals. A chair with adjustable height and back support is also required. If the desk and chairs are in an area with tiled floors it is recommended that chairs without wheels are provided.

Cleaning the laboratory

Wiping the desk before and after using chemicals, mopping the floor, and keeping the apparatus clean in the cabinet or with the cover on are necessary to keep the well-organized laboratory. Dust has a bad influence on equipment and causes contamination.

Any cleaning staff who are employed to clean the offices who may also clean the laboratories must be

- provided with the appropriate safety clothing,
- provided with the appropriate cleaning equipment and cleaning solutions
- instructed with regard to the dangers and hazards within the laboratory.

(2) Management of Equipment

The procedure for the management of equipment can divided into the following steps. Documentation is required in each step.

- Installation
- Initial training
- Operation
- Maintenance and Repair
- Disposal

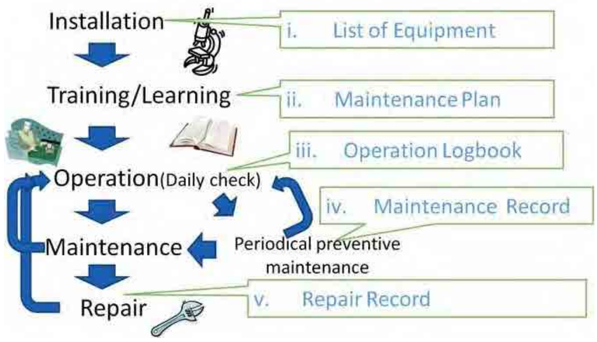


Figure 5.3-3 Flow of Equipment Management

The role of each division is to be clarified when new equipment is installed.

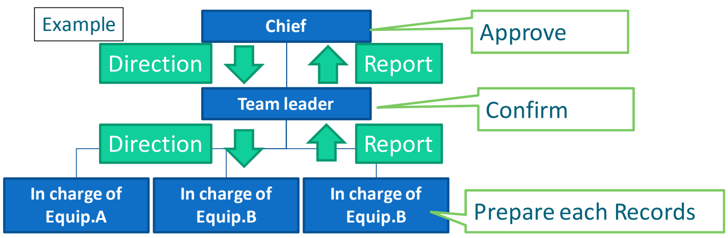


Figure 5.3-4 Example of clarification of roles

Installation

When new equipment is installed in a laboratory, the equipment is to be registered on the "List of Equipment". A unique identity number for the piece of equipment must be registered at the time of the registration. A tag showing clearly the identity number must be attached to the equipment.

Example

List of Equipment
Danh sách Thiết bị

Updated(Cập nhật):
Approved by(Xác nhận bởi):
Prepared by(Chuẩn bị bởi):

ID	Name of equipments	Serial number	Model	Manufacture	Supplier	Installation Date	Installation place	In charge of
Ký hiệu	Tên thiết bị	Số Seri	Loại Model	Nhà sản xuất	Nhà cung cấp	Ngày lắp đặt	Nơi lắp đặt	Người phụ trách
12-WP	Water purifier		Aquatron Automatic Water Stills A4000D	Bibby Scientific - UK	Phan le	2012/2/12		

➢To Label on the equipment

Name	UV-VIS
ID	12-XX-XXX
In charge of	Mr.A
Next Regular check day	August, 2012

Figure 5.3-5 List of Equipment

Initial Training

In general when a complex piece of the equipment is installed, initial training will be conducted by the supplier. In the training courses, laboratory staff should confirm how frequently the equipment needs maintenance, and what kind of maintenance is required for the equipment.

After the training laboratory staff should prepare the maintenance plan as follows. Usually, periodical maintenance is conducted every six months.

Example

No	Name of equipment	ID	Month												Note
			1	2	3	4	5	6	7	8	9	10	11	12	
1	PH meter	TA02-A		○						○					-Periodical preventive-maintenance -Check the stock of required spare parts
				○			○			○			○		Exchange the parts of XXX

Figure 5.3-6 Example of Maintenance Plan

Operation

An Operation Logbook should be prepared to record the daily operation and maintenance by the analytical operators. Example of an Operation Logbook is shown as follows.

NAME OF EQUIPMENT	PH meter
MANUFATURER	TOA-DKK
MODEL	HM-30R
ID	TA02-A
RECEIVED DATE	27/02/2012
OPERATOR	Mr. A

➢Should be recorded **at the everyday of measurement**
➢Check points depend on equipment → See manuals

Temp (℃)	std phthalate compound std	std neutral phosphate	std borate salt
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14

Example

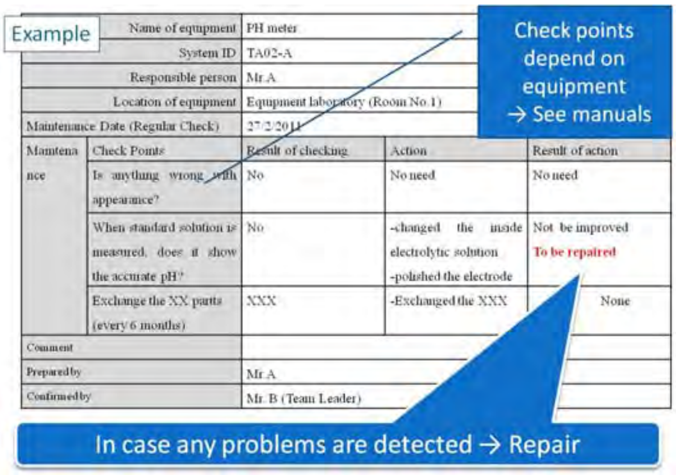
Date	Operator	Calibration results (Accuracy to be maintained : ±0.02)						Number of sample	Equipment condition	Note
		Expected Value	Measured Value	Expected Value	Measured Value	Expected Value	Measured Value			
28/2/2012	X X	4.01(24℃)	3.99(24℃)	6.86(24℃)	6.87(24℃)	9.18(24℃)	9.17(24℃)	20	Not particular	
29/2/2012	X X	4.00(25℃)	4.00(25℃)	6.86(25℃)	6.80(25℃	9.18(25℃)	9.17(25℃)		To be checked	

In case any problems are detected → Maintenance/Repair

Figure 5.3-7 Example of Operation Logbook

Maintenance

Maintenance should be carried out in accordance with the maintenance plan. A form is used to record the results of the maintenance activities. An example is shown as follows.



Example

Name of equipment		PH meter		
System ID		TA02-A		
Responsible person		Mr.A		
Location of equipment		Equipment laboratory (Room No.1)		
Maintenance Date (Regular Check)		27/2/2011		
Maintenance	Check Points	Result of checking	Action	Result of action
	Is anything wrong with appearance?	No	No need	No need
	When standard solution is measured, does it show the accurate pH?	No	-changed the inside electrolytic solution -polished the electrode	Not be improved To be repaired
	Exchange the XX parts (every 6 months)	XXX	-Exchanged the XXX	None
Comment				
Prepared by		Mr.A		
Confirmed by		Mr. B (Team Leader)		

Figure 5.3-8 Example of Maintenance Record

Repair

When a problem with the equipment occurs, the equipment must be repaired as soon as practicable. The repair record must be kept in the laboratory. The detail information contained in he record is useful for maintenance activity in the laboratory. The record can be referred to if and when the same trouble occurs again in the future.

Disposal of Capital Equipment

The depreciation period of capital equipment in a laboratory is between five and twenty years. The capital and operational budgetary plan of the laboratory must be prepared to allow for depreciation of existing equipment and the purchase of new equipment.

The procedure for final disposal of old equipment should be discussed with the manufacturer at the time of purchase.

(3) Management of Chemicals

Procedure of management of chemicals can divided into the following steps. Some chemicals are very toxic. Therefore it is necessary to manage the chemicals strictly.

- Purchasing
- Usage and Disposal
- Periodically Check

Figure 5.3-9 Flow of Chemical Management

Handling of Chemicals

All new staff must be given induction training during which time they will be trained in issues relating to safe working with chamicals..

a) Concentrated acids (HCl, HNO_3, H_2SO_4 etc)

When dilution of acids is necessary, add the concentrated acid to a larger volume of water. Highly acidic liquid is volatile. Therefore, these chemicals must be used in the fume food.

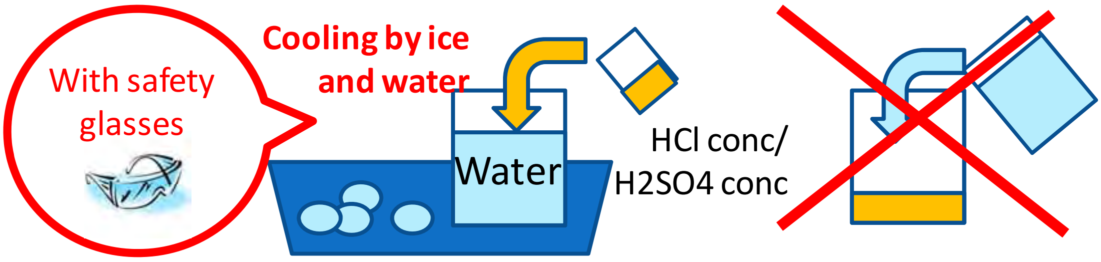


Figure 5.3-10 Handling Acid Reagent

b) Concentrated base (NaOHaq, KOHaq etc)

When dissolving the base into water, it might make high heat. Therefore, it is recommendable to cool the solution by water and ice. When preparing Winkler alkali-iodide-azide reagent particular care must be taken to add only small quantity of the NaOH pellets at a time to the water.

c) Other chemicals

It is recommended that MSDS (Material Safety Data Sheet) are check before purchase..

Figure 5.3-11 MSDS

MSDS

Laboratory staff should have the knowledge of chemicals. To handle the chemicals, MSDS (Material Safety Data Sheet) supply useful information for laboratory staff. A copy of the requisite MSDS sheet must be kept on file for each chemical in use in the laboratory.

Purchasing and Usage

When a laboratory purchase a chemical, it is necessary to register it into "Inventory List of Chemical".

In the list, the following information is recorded.

- Special code for each chemical
- Name of the chemical
- Level of Quality (Grade and Purity)
- Manufacturer
- Date of purchasing
- Date of opening the bottle
- Date of disposal

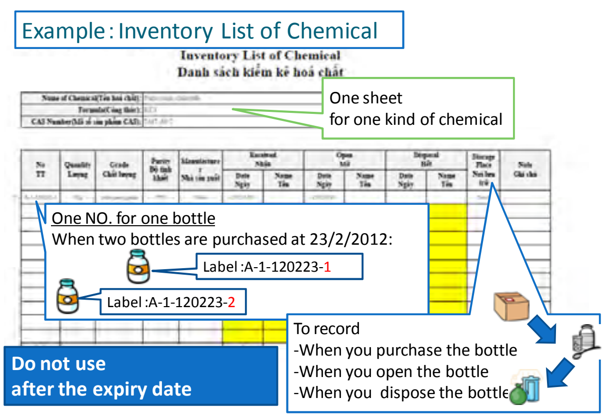


Figure 5.3-12 Example of Inventory List of Chemicals

Each use of the chemical should be recorded in the inventory listing date used, amount used and name of person using the chemical. Such records allow the chemical stock to be managed enables timely and cost effective purchasing of replacement chemicals.

Chemical storage is to be designed considering the character of the chemicals. For instance, flammable liquid, such as organic solvent, should be separate from oxidizing material, such as sulfuric acid.

Toxic and/or Harmful chemicals should be separate from others and keep in the place which can be locked.

	Toxic and /or Harmful		Not Toxic nor Harmful	
	Solid	Liquid	Solid	Liquid
Oxidizing	Group1	Group4	Group7	Group10
Flammable	Group2	Group5	Group8	Group11
Others	Group3	Group6	Group9	Group12

Figure 5.3-13 Separation of Chemicals

<u>Periodically Check</u>

Amount of chemicals in the laboratory should be check periodically to confirm the usage of the chemicals.

(4) Management of Wastewater

Wastewater from laboratory is to be separated by the character of the wastewater. Especially, wastewater which contains CN(cyanogen), such as wastewater of CN analysis and NH_3 analysis, must not be mixed with acid. The pH of wastewater containing CN should be kept at more than 11. Otherwise, CN gasses, very toxic gas, will generate in the laboratory.

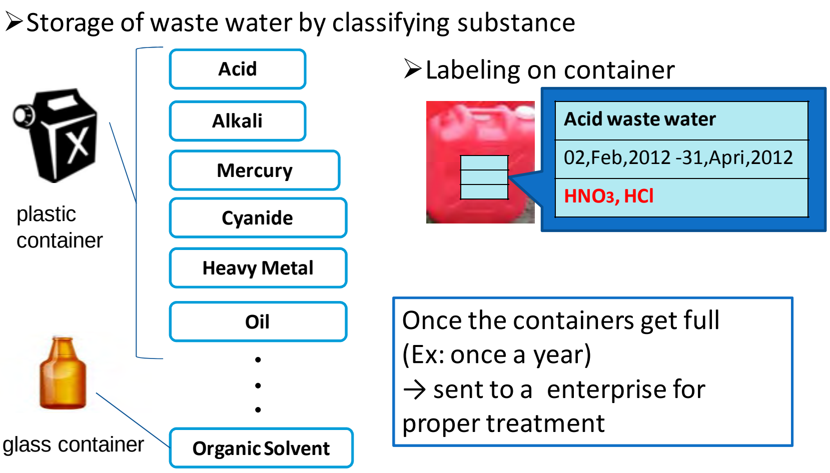


Figure 5.3-14 Management of Wastewater

5.3.2 Quality Assurance (QA) and Quality Control (QC)

Quality Assurance and Quality Control (QA/QC) procedures and a clear delineation of QA/QC responsibilities are essential to ensure the utility of environmental monitoring data. Quality assurance (QA) refers to the overall management system which includes the organization, planning, data collection, quality control, documentation, evaluation, and reporting. Quality control (QC) refers to the routine technical activities whose purpose is, essentially, error control.

According to "Standard Method for the Examination of Water and Wastewater (18th edition, 1992)", the word QA is defined as "a definitive plan for laboratory operation that specifies the measure", and

QC is defined as "set of measures within a sample analysis methodology to assure the process is in control".

This Section proposes some ideas to improve QA/QC level of the water quality monitoring as shown in Table 5.3-1. Detailed procedures should be implemented by reference to Circular 10/2007/TT-BTNMT guiding QA/QC .

Table 5.3-1 Proposed Ideas for Improvement of QA/QC Level

Category	Proposed Ideas	Section
QA	Standard Operation Procedure (SOP)	Section (1)
	Chain-of-Custody	Section (2)
QC	QC Sample	Section (3)
	Internal QC	Section (4)
	External QC	Section (5)
Common (QA/QC)	QA/QC in Data Processing and Reporting	Section (6)

(1) Standard Operation Procedure (SOP)

Standard Operation Procedures (SOPs) are the fundamental document which assure the quality of monitoring results. Table 5.3-2 shows the activities for which Standard Operation Procedures should be prepared.

Table 5.3-2 Contents to be Included in SOPs

No	Area of Activity	Activities for which SOPs are Required
1	Sampling	(1) sampling procedure, (2) record format, (3) type of vessels to be prepared, (4) pre-treatment method, (5) field analysis method, (6) water flow measurement procedure, (7) safety management measure (8) maintenance of sampling equipment, (9) training program
2	Transportation and storage of samples	(1) transportation procedure, (2) equipment to be prepared for transportation, (3) record format, (4) required storage condition, (5) storage period of samples
3	Analysis	(1) list of analytical determinand, (2) analytical method applied, (3) management system of standard and reagent, (4) internal quality control system such as duplicate analysis, usage of spike sample or reference material, (5) validity checking of analytical result, (6) training program
4	Maintenance of equipment	(1) list of equipment, (2) regular maintenance program, (3) calibration program though analytical work, (4) regular calibration program
5	Test report	(1) format of test report, (2) media to be used, (3) information sharing procedure with other organization

Test methods that serve as a basis for measurement certification depend on methods (official methods, such as TCVN) prescribed by the state or local government in the relevant ordinances. These authorized methodologies should be prepared as Controlled Documents and given a unique internal SOP code .number.

When there is no official method, or it is difficult to conduct measurements stated in an official method, a laboratory manager shall prescribe an appropriate method to produce an accurate result beforehand. For each method an SOP must be prepared which documents the methods, and describes an applicable scope, lower limit of determination and significant figures, in addition to aspects that greatly affect accuracy, risky areas, "tricks," etc. This in turn must be issued as a Controlled Document and assigned its own unique internal SOP code .number together with a version number.

If changes are to be made in analysis methods that are not official methods, it is necessary to confirm adequacy of the analysis method (analysis method validation).

Controlled Copies of SOP Documents should only be issued by the laboratory manager. Each copy will be numbered and a record kept of the holder or its location. In the event that changes are made to an SOP the SOP is reissued with the same code number and a new version number. All copies of the previous version must be collected and destroyed. Only by this means can the laboratory manager be sure that the SOP in use is the current one.

It is recommended that ad hoc copies of Controlled SOP are not made. If such copies are made they must be stamped PERSONAL COPY ONLY. Anyone found using a non-current SOP while carrying out a laboratory or field activity should be given a verbal warning. .

(2) Chain-of-Custody

The main activities of field survey and laboratory work associated with water quality monitoring are preparation, sampling, transportation, storage, and laboratory analysis. Normally, the persons in charge of laboratory analysis and the other activities are different; therefore the potential exists for some misunderstanding (eg. mistake in delivery, mistake in determinand) may occur when samples or information are handed.

In order to conduct the sampling, the sampling receipt, and sample analysis smoothly and effectively, "Chain-of-Custody" procedures should be employed. Chain-of-Custody can be defined as "*Procedures used to protect samples from tampering and to document such protection*". The example of "Chain-of-Custody Format" is shown in Table 5.3-3.

Table 5.3-3 Sample of Chain-of-Custody Format

Sampling Info.	Monitoring Type		No. of Sample	
	Station Name & Code		Sample Volume (L)	
	Sample Code		Sample Type	
	Sampling Date		Preservation Method	
	Sampling Time		Note	

Analyzed Info.	Required Determinands Analyzed	

Delivery Info.	Item	Signature in Charge	Date	Item	Signature in Charge	Date
	1) Sampling			3) Storing		
	2) Transportation			4) Analyzing		

(3) QC Sample

There are two kinds of QC samples.

One is a sample intended to measure the precision of the whole sampling and analysis procedure. The QC sample is taken at same sampling station with primary samples. The QC sample should not be given the same name as the primary sample. The format of the labeling should be the same but a dummy name and different time should be used. After getting analysis results from the laboratory, the QC sample should be compared as the Duplicate Analysis (see Section (4)).

The other QC sample is a sample for measuring travel blank. Travel blank tests level of contamination from the sampling preparation time to the sample analysis time.

(4) Internal QC

Internal Quality Control (IQC) focuses on an individual method and tests its performance mathematically. This section introduces following items of IQC.

- Calibration curve
- Double check

Calibration Curve

Before any analytical methods are put into routine use, it is essential that they be validated properly. The following sets of measurements should be performed as a minimum program of validation.

a) Linearity:

A calibration curve should be made and a linear response should be demonstrated. If a calibration curve does not show a linear response, it is necessary to check the concentrations of the standard solutions.

If a calibration curve is being used, standard solutions should be analyzed along with the field samples from time to time within a required range of concentration. An ideal calibration curve is linear with a regression coefficient (R^2) of 0.99 or greater.

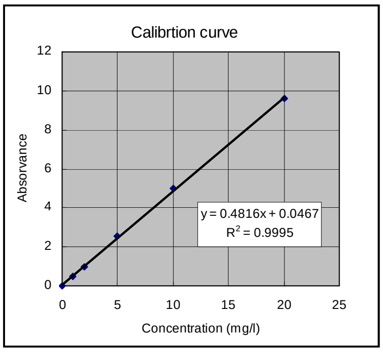


Figure 5.3-15 Calibration curve

b) Blanks:

At least one blank sample should be analyzed with each batch of samples. A blank of reagent water, usually distilled water needs to be checked. The analysis of a blank should not yield a value higher than that allowed by acceptance criteria. This procedure checks interference and a limit of detection of assay.

c) A built-in calibration curve:

Even in the case of equipment such as spectrophotometer with a built-in calibration curve, the calibration curve should be checked by standard solutions at least once per month.

d) Recovery check:

After finishing the batch of an analysis, one of standard solutions should be measured again. Then the value of the standard solution should be within 95-105% of the value of the calibration curve.

Control by Double Check (Precision Control)

Use of double check as a method of checking precision has two distinct advantages: quality control materials are matrix-matched, and the materials are readily available at no extra cost. If samples are analyzed using a same method such as equipment and reagents, it is considered that all results are fluctuated by a same influence.

Results obtained by the duplicate analyses can be used to calculate a coefficient value, CV, which is calculated by using following equation:

$$CV(\%) = \frac{\sigma}{(X_1 + X_2)/2} \times 100(\%)$$

Where
X_1 and X_2 are the duplicate results from an individual sample
σ is the standard deviation of X_1 and X_2.

Standard deviation, σ, can be calculated by following equation:

$$\sigma^2 = (X_1{}^2 + X_2{}^2)/2 - \left(\frac{X_1 + X_2}{2}\right)^2$$

$$\sigma = \sqrt{\sigma^2}$$

These CV values should be within a range of 0 - 20%. When any values are greater than 20%, an analytical procedure is out of control.

(5) External QC

External Quality Control (EQC) is a procedure for improving accuracy of analytical methods and procedures by comparing results of analyses carried out in one laboratory with the results by other laboratories carrying out the same analysis on the same material.

This is process is usually coordinated by an accredited reference laboratory that prepares and circulates sets of samples with known and unknown concentrations of environmental determinands of interest to the participating external laboratories.

Each participating laboratory measures the concentrations in the samples and reports the results to the reference laboratory.

Results from all participating laboratories are collated by organizers of EQC program and then subjected to detailed statistical analysis. A report to each laboratory is generated, giving a target value for a reference sample or samples (usually consensus mean or median), a histogram illustrating distribution of results for each material, and an individual performance score relating individual laboratory results to the target value.

(6) QA/QC in Data Processing and Reporting

<u>Management and Processing Data</u>

1) Copies of monitoring activity log-sheets compiled in field should be handed to the laboratory staff who will be able to refer to them when examining the analysis result to check the reliability of the data.

2) All originals of documents and records relating to monitoring activities should be kept and managed as regulated.

3) Field measurement data and laboratory analysis should be checked, calculated and processed. The checked points to be used in the process should be listed in an SOP.

Photo: Data Storage

<u>Receipt of Laboratory Analysis Data</u>

1) Test Report
The analysis data should be described in a testing report. It is possible to judge whether a laboratory is reliable or not by examining the information submitted in their testing reports.

It is recommended that a test report includes, when appropriate, the following information,

- ✓ Title (e.g., "Saigon River Water Quality Report – October 2012")
- ✓ Name and address of laboratory, and location where analysis were carried out if different from an address of laboratory
- ✓ Unique identification of a test report (such as a serial number), and on each page an identification in order to ensure that a page is recognized as a part of the test report, and a clear identification of the end of test report
- ✓ Name and address of customer
- ✓ Test methods used

- ✓ Description and condition of the samples tested, and comments on any samples submitted with unclear identification, damaged or insufficient volume.
- ✓ Date of receipt of test samples (where this is critical to validity and application of results) and dates of performance of test
- ✓ Test results with, where appropriate, units of measurement
- ✓ Results of all QC blanks, standards, spikes and duplicates measured during the analysis of the samples. Limits of detection or limits of reporting for each determinand should also be included in the report.
- ✓ Name, function and signature or equivalent of person authorizing a test report to whom any questions relating to the report should be communicated.
- ✓ Hard copies of test reports include page numbers and total number of pages.

2) Significant Figures

The significant figures of a record are the total number of digits which comprise the record, regardless of any decimal point. Thus 6.8 and 10 have two significant figures, and 215.73 and 1.2345 have five. By definition, continuous measurement data are usually only an approximation to the true value. Thus, a measurement of 1.5 may represent a true value of 1.5000, but it could also represent 1.45 or 1.54.

Hence, a system is needed to decide how precisely to attempt to represent the true value. Data are often recorded with too many, and unjustified, significant figures; usually too many decimal places. Some measuring instruments may be capable of producing values far in excess of the precision required (e.g. pH 7.372) or, alternatively, derived data may be recorded to a precision not commensurate with the original measurement (e.g. 47.586 %).

In water quality analysis field, the result value is rounded to two or three digits. When DONRE staff find the result of which significant figure is over four, the laboratory should check the record and apply the correct significant figures.

Frequently, water samples contain concentrations of determinands which are below the limit of detection or limit of reporting of the laboratory at the time of measurement of the samples. These results are to be reported as not detected (ND) or less-than value (< [Lower Detection Limit]). The numerical value must be included in the report.

3) Comparison of Data

The following items are given as a method for judging validity of a result of analysis which have been reported by an external contracted laboratory.

a) Chorological (regional) and horizontal: By comparing the incoming results with data which was measured in upper and lower side of a river basin, we can evaluate the validity of data. When an extreme data are founded comparing with other data, a measurement might have a mistake in a procedure. Potential extreme values can be evaluated statistically to identify whether they are rogue values – See Statistical Handbook Section 4.2

b) Past data reference: By comparing the new values with data which was measured in the past, we evaluate validity of data. When an extreme data are founded comparing with past data, a measurement might have a mistake in a procedure. Potential extreme values can be evaluated statistically to identify whether they are rogue values – See Statistical Handbook Section 4.2

c) Physical characters: Validity of measured data is evaluated by considering physical quantities such as solubility and stability-constant.

e.g. The saturation concentration of dissolved oxygen is determined by the temperature and salinity of water. It is unusual to exceed the saturation concentration by more than 10%

e.g. Nitrite nitrogen is quickly oxidized to form nitrate nitrogen. Therefore in natural waters concentrations of nitrite nitrogen are almost always less than those of nitrate nitrogen in the same sample.

d) Other determinands: The validity of measured data is evaluated by examining it in relation to different determinand.

e.g. Conductivity is proportional to a sum of main dissolved ions in the water. Therefore, in tidal areas concentrations of chloride ions, which are one of the main components of sea water and conductivity are in proportion to each other.

e.g. Concentration of total nitrogen is a sum of nitrate-nitrogen, nitrate-nitrogen, ammoniacal nitrogen and organic nitrogen. So each component should be present in a lower concentration than total nitrogen.

e.g. Turbidity and suspended solids are in proportion to each other in waters in which the suspended solids are of a similar particle size.

e) Condition of Sampling Site: Validity of measured data is evaluated by considering relationship between a condition of sampling site and water quality of river.

f) Accurate recording: Out of foregoing check items, following items are easy to be miswritten.

e.g. Unit inconsistency of conductivity

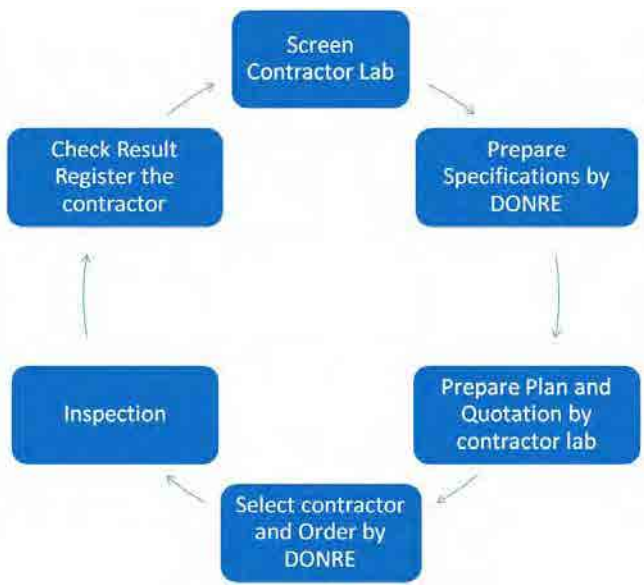
Conductivity can be expressed in a number of units (mS/m, μS/cm, S/m). Relations among units are, “1S/m＝1,000mS/m = 10,000μS/cm”.

e.g. Conversion of Nitrogen

Nitrate nitrogen (NO_3-N) and nitric acid ion (NO_3) are sometimes listed in a same line. It is necessary to convert from NO_3 to NO_3-N when we compare data with a standard value.

5.4 QC for Contract Work

A laboratory or monitoring section may, at times, outsource work to another laboratory for a number of reasons. These include unforeseen circumstances, workload, and specific technical expertise. The work must be contracted to a technically competent laboratory. This section proposes a way to control the quality of outsource laboratories.



A policy for the outsourcing is discussed at first. Then, detail methods of the QC are explained in the section.

- Screen contractor laboratory,
- Preparation of specification by DONRE,
- Preparation of work plan and quotation by the contractor laboratory,
- Selection and ordering by DONRE,
- Inspection, and
- Checking result are the activities in the contract work.

Only then, when the DONRE has confirmed that the contractor laboratory performs well, the can the laboratory be considered as a candidate of the next contract work. The final quality of the contract work is controlled by the successful completion of these six activities.

5.4.1 Policy

To control the quality of the contract work, DONRE must have a policy with regard to contract work as follows.

- **DONRE is responsible to their customers for any contractor's work carried out.**
- **It is responsibility of the Quality Manager in the DONRE to assess and approve the competency level of any subcontracted laboratory.**

So, when PPC or other customer of DONRE have a complaint about the report prepared by DONRE using the contractor laboratory it is the responsibility of the DONRE to resolve all issues relating to the work carried out by the sub-contractors.

5.4.2 Screening

Screening is an important part of the process for selection of candidates for contract work. The candidates are selected from laboratories which demonstrate technical competence by possession or receipt of one or more of the following:

- VILAS
- Performance has been confirmed by QC sample or reference material
- Audited by DONRE's auditors

For example, a laboratory that showed good performance in the previous contract work would be audited by DONRE's auditors.

It is essential that the laboratory are able to demonstrate that they have the necessary staff and equipment resources to be able to carry out all of the measurement within the recommended storage time for each of the determinands to be measured. The laboratory must also be prepared to certify that each batch of analysis was carried out within the permitted storage period.

5.4.3 Preparation of the Specification

(1) Contents of the Specification

After screening the candidates, DONRE will send the specification which asks the candidates to prepare work plan of the contract work. In the specification, DONRE writes not only the contents of the monitoring but request related to QC and request the laboratory to accept inspection. An example of the specification contents is as follows.

Contents of the Specification

1. Request to the subcontractor to submit their Work Plan
2. Contents of the environmental monitoring program
   - Purpose of the environmental monitoring program
   - Deadline of the subcontract work
   - Place, Sample Name, Type of water body (River, Lake, etc)
   - Analysis determinands
   - Analysis Methods (are to be Standard Method)
   - Method of Sampling, Transportation, and Preservation
   - Result format
3. Request Action to be taken for Abnormal Result (See Section 5.4.3 (2))
4. Request Data for QA/QC (See Section 5.4.3 (3))

(2) Request Action to be taken for Abnormal Result

When DONRE finds an abnormal result in the report or the certification of the contractor laboratory, DONRE asks the laboratory to explain the reason or to re-analyze the sample. However, in some

cases this may beyond the recommended holding time for the sample. There is frequently an un-necessarily long delay, in some cases months, between the time of receipt of samples and the submission of the report to the DONRE. In most cases the samples will be beyond their maximum holding time and are likely to have been discarded.
To avoid the situation, DONRE should request the laboratory to take the following actions when they find the abnormal result during the analysis.

Action to be taken for the Abnormal Result

a. When subcontractor laboratory find an abnormal result during the analysis, the subcontractor has to inform DONRE as soon as possible.
b. The subcontractor should check the reason of the abnormal result.
c. The subcontractor should re-sample and/or re-analyze the sample in case. In the case of an industrial effluent this is a practicable option. However, particularly in the case of river sampling, resampling for a single determinand is not an option. This is because determinands are not evaluated individually but as part of the whole pollutant relationship and consequently a complete sample would need to be re-analysed for all the measured determinands. More significantly, the river is assessed as a whole and not on a station by station basis and in such cases the whole of the set of stations would need to be resampled.

When DONRE requests the laboratory to take action for the abnormal result, DONRE should define the criteria between abnormal and normal results in the specification. The criteria is defined by the condition of each sampling points and each monitoring determinand, and by the policy of each DONRE.

Examples of the definition of the abnormal result are shown as follows.

Definition of Abnormal Result (Example for effluent discharge samples)

a. Over Wastewater Standard Value
b. Higher than past result (ex. Over 3 times of the average of last 5 years)
c. Over the value which DONRE selected (ex. 1/2 of the Wastewater Standard Value)
d. Over the Highest value of last year**.**

Definition of an Abnormal Result for environmental samples.
The screening for an abnormal result from environmental samples is considerably more difficult that for effluent discharge samples. The screening of data is the subject of Chapter 4 of the Statistical Handbook (See Appendix 3 of this Handbook) and is described there in detail.

(3) Request for QA/QC
In the specification, DONRE will require the laboratory to set up a section, named quality management section, for checking data, and to select a responsible person who is responsible for quality management in the section. DONRE requests the laboratory to conduct internal quality control (see 5.3.2 (4)) and make available to DONRE the results of the internal quality control as evidences of the activities.

5.4.4 Preparation of Work Plan

As response to the specification, each candidate laboratory prepares a work plan. Expected contents of the work plan are as follows.

Contents of the work plan

a. Contents of the Inspection or Environmental Field Sampling
b. Formation for the activity (QC section, Representative for the Quality, Network in emergency case, System to check data)
c. Schedule of the activities

d. Reply of request from DONRE (Action for abnormal result, QA/QC)

5.4.5 Selection of the Contractor laboratory

After checking the work plan and the quotation submitted by the candidate sub-contractors, DONRE can select the contract laboratory. Before issuing a formal contract DONRE should check detail of the laboratory's proposal, resolve any difference between the specification and the work plan and revise the contract to reflect any changes that need to be made.

For example, if the laboratory are unable to carry out a water quality analysis by the method mentioned in the specification, the laboratory must propose an alternative recognized and approved analysis method in their work plan. If DONRE are unable approve the proposed alternative DONRE are entitled not to select the laboratory as the contractor.

5.4.6 Inspection of the Contract Work

DONRE should inspect the contractor's activity at any time. There are two types of inspection which are field inspection and laboratory inspection.

- Field inspection is joining the contractor's field work and checking their activities.
- Laboratory inspection is visiting the contractor's laboratory and checking their activities in the laboratory.

Key points for checking in the two inspections are as follows.

<u>Check points in Field Inspection</u>

a. The contractor's person in charge of the field work is present on site
b. Place and Date/time is same as the plan
c. Sampling equipment and sample bottle are appropriate and clean
d. Sampling is being conducted appropriately
e. Basic data (weather, water temperature, air temperature, appearance, name of the person sampling) are all recorded in the field log book or log sheet
f. Sampling and on-site measurement are conducted as planned
g. Volumes of sample are enough for analysis (for duplication analysis in case) See attachment
h. Sufficient suitable cool boxes at the correct temperature (4^oC) for cooled samples are available
i. Appropriate volumes of the chemicals are added where samples require fixing at te time of collection
j. Labeling is accurate and any required photographs have been taken and logged.

<u>Check points in Laboratory Inspection</u>

a. Laboratories are clean enough to avoid contamination
b. Equipment is maintained based on SOP submitted and condition is recorded
c. Glassware looks clean enough to avoid contamination
d. Reagents are put in Chemical Storage
e. Name and other information are labeled on the reagent bottle
f. Samples are preserved following SOP
g. Analysis is conducted following SOP
h. Internal Quality Control is conducted as mentioned in the Plan.
i. Results of the internal quality control are recorded
j. Countermeasures are conducted as planed
k. Results of past 5 years are recorded

When DONRE find any mistakes of the contractor through the inspection, DONRE suggests the contractor to correct the points.

5.4.7 Checking Result

Before checking the result from the contractor laboratory, DONRE should establish a system to check the results in DONRE. Who will check? Who is the person in charge of the result? How to register the data? These questions are to be clear before receiving the result.
Key points for checking result are shown in the Section 5.3.2 (6).
The outline of checking the result is as follows.

<u>Outline of Check Result</u>

a. Check any careless mistake
b. Check Significant figures
c. Compare the result against environmental standard values
d. Compare the results against past data
e. Check the relationship between determinands

CHAPTER 6 DATA ANALYSIS

6.1 Statistical Approach to Data Analysis

6.1.1 Origins of measured variation.

Systematic variation in water quality can be defined as that variation which exists as a result of a change in water quality having taken place. Random variation in water quality can be defined as that variation which is caused by many irregular, erratic, individually unimportant fluctuations or chance factors that in practical terms cannot be anticipated, identified or eliminated. These two variations combine to give rise to the variability of water quality in the environment.

The task of statistical analysis is to separate and quantify the two and thereby identify the true magnitude of the systematic change.

6.1.2 Estimation of the random variation

The magnitude of random variation can be estimated by carrying out a number of procedures which will identify the source and magnitude of the variation. This is carried out visual examination of the river has been carried out to identify the most representative sampling site. The decision as to where to position the sampling point and how to sample have been out lined in Section 4.2 of this Handbook and the various TCVN documents listed in that section. Having decided on the location and the sampling method it is necessary to examine the random variability.

The variation can be attributed to two main areas of activity, the field and the laboratory. Methods for estimating the size of the variation for the different areas and sub areas are described below. This assumes that, during routine sampling, only a single sample is to be presented to the laboratory for analysis.

A. Field – this is the area where the greatest variability will be encountered.
   i. Lateral variation across the river channel: Take at least three simultaneous samples over the width of the river at ¼, ½, ¾ rivers widths.
   ii. Longitudinal variation (Short term): At the same locations used above take two further samples at ten-minute intervals.
   iii. Analyse all nine samples separately and calculate the mean and standard deviations for lateral and longitudinal variations.
   iv. Identify the sources of the greatest variation to determine whether lateral and/or longitudinal composite sampling is necessary to minimise the standard deviation around the single samples to be sent for analysis.

B. Laboratory sub-sampling – this is the area where intermediate variability will be encountered.
   i. From the single sample bottle received in the laboratory take a minimum of three replicate sub samples and carry out the normal laboratory procedure for the measurement.
   ii. Calculate the mean and standard deviation of the replicate samples to determine the sub-sampling variability.

C. Laboratory Measurement – this is the source of the smallest variability and is described in Appendix 2 of this Handbook.

The area in which the attention to minimizing the variability of measurement is in the field sampling and should be the priority area for attention in new and existing monitoring programs.

It is only when the variability around a single measurement is known that any statistical analysis can be carried out. Since most of the data collected form part of a normal distribution, with the inherent property that the variance is independent of the mean, it not necessary to calculate the standard deviation on every sampling occasion. Once having established the standard deviation it is only necessary to repeat the process if some change in the sampling environment that is likely to affect the variability occurs.

6.2 Basic Data Analysis in Surface Water Area

Data should be collected and analyzed to meet each objective of the water quality monitoring plan. It must be easily understandable in order to support water quality management and pollution control. This handbook shows the following examples of data summarization of each objective by using tables, graphs and figures:

- Evaluation of compliance with water quality standard and water use (drinking, recreation, fishery and etc),
- Identifying the impacts of contaminants released from pollution sources,
- Establishing the status of water quality in order to define a baseline condition,
- Identifying the serious pollution sources (critical areas) within the river basin, and
- Considering measures for water quality protection using the forecast from previous trend and subsequently monitoring their effectiveness.

6.2.1 Analysis by Raw Monitoring Data

(1) Evaluation by Using a Table

Using a table is a simple method to evaluate compliance with water quality standard and water use (drinking, recreation, fishery and etc). An example is shown in Table 6.2-1. The determinands which exceeds the water quality standard can be highlighted by hatching.

Table 6.2-1 Example of Evaluation of Adequacy of Water Quality Standard (Using a Table)

Highlight to Exceed TCVN “A”

Highlight to Exceed TCVN “B”

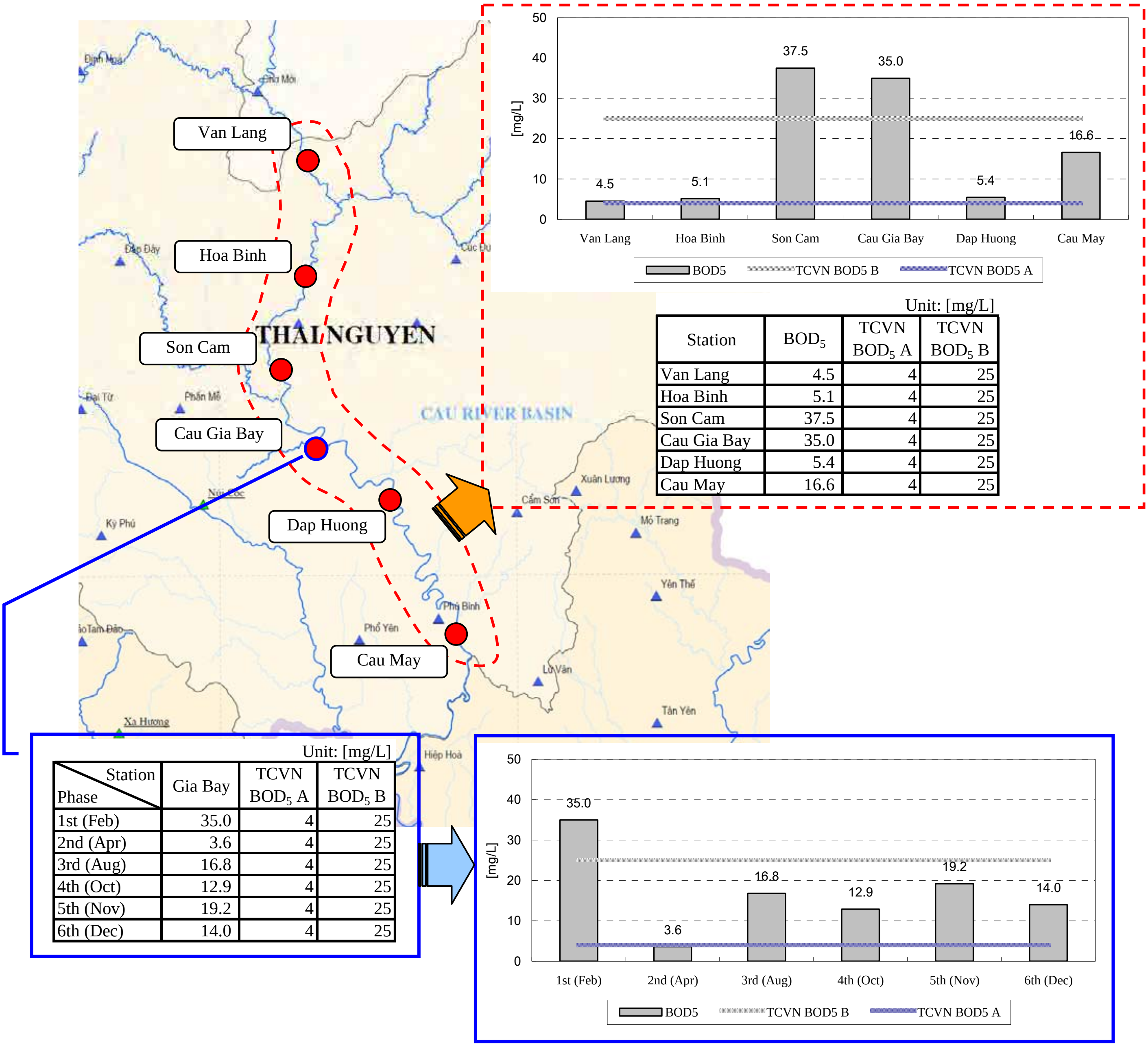
Code	Parameter	Unit	Station NM1	Station NM2	Station NM3	TCVN 5942-1995 A	TCVN 5942-1995 B
1	pH		7.1	7	7.7	6.5-8.5	5.5-9
2	Turbidity	NTU	4.5	4.7	11.6		-
3	BOD_5	mg/L	4.3	5	39	<4	<25
4	COD	mg/L	8.6	9	50	<10	<35
5	DO	mg/L	6.8	6.6	4.5	6≧	2≧
6	SS	mg/L	34.6	37.2	74.1	<20	<80
7	Pb	mg/L	ND	ND	ND	<0.05	<0.1
8	Mn	mg/L	0.068	0.059	0.073	<0.1	<0.8
9	Fe	mg/L	0.355	0.317	0.369	<1	<2
10	Cr (VI)	mg/L	ND	ND	ND	<0.05	<0.05
11	NO_2^-	mg/L	0.15	0.18	0.3	<0.01	<0.05
12	NH_4^+	mg/L	0.09	0.1	0.21	<0.05	<1.0
13	F^-	mg/L	0.16	0.21	0.2	<1	<1.5
14	As	mg/L	0.003	0.002	0.007	<0.05	<0.1
15	Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.001	<0.002
16	Coliform	MPN/100mL	4600	5500	17000	<5,000	<10,000

Note: (light hatching): Exceed Standard A Level, (dark hatching): Exceed Standard B Level
NM1: Cau River’s water at ferry- boat bridge, Bac Kan Town
NM2: Cau River’s water at Gieng waterfall, Bac Kan Town
NM 3: Cau River’s water at discharge point of Pulp Factory, Bac Kan Town

Source: Back Kan DONRE

(2) Evaluation by Using a Graphical Method

Using a graph is also a simple method to evaluate the compliance of measured water quality with the water quality standard that is applicable to the water usage. An example is as shown in Figure 6.2-1. The time and/or location at which the determinand exceeds the respective water quality standard can be identified by comparing bar chart with the line showing the level of the water quality standard.



Unit: [mg/L]

Station	BOD_5	TCVN BOD_5 A	TCVN BOD_5 B
Van Lang	4.5	4	25
Hoa Binh	5.1	4	25
Son Cam	37.5	4	25
Cau Gia Bay	35.0	4	25
Dap Huong	5.4	4	25
Cau May	16.6	4	25

Unit: [mg/L]

Station / Phase	Gia Bay	TCVN BOD_5 A	TCVN BOD_5 B
1st (Feb)	35.0	4	25
2nd (Apr)	3.6	4	25
3rd (Aug)	16.8	4	25
4th (Oct)	12.9	4	25
5th (Nov)	19.2	4	25
6th (Dec)	14.0	4	25

Figure 6.2-1 Example of Evaluation of Compliance with Water Quality Standard (Using a Figure)

(3) Evaluation by Using a Map

Using a visual map is another method to show compliance with water quality standard and water usage. An example is shown in Figure 6.2-2. The locations where the determinand which exceeds the water quality standard can be highlighted by different colors.

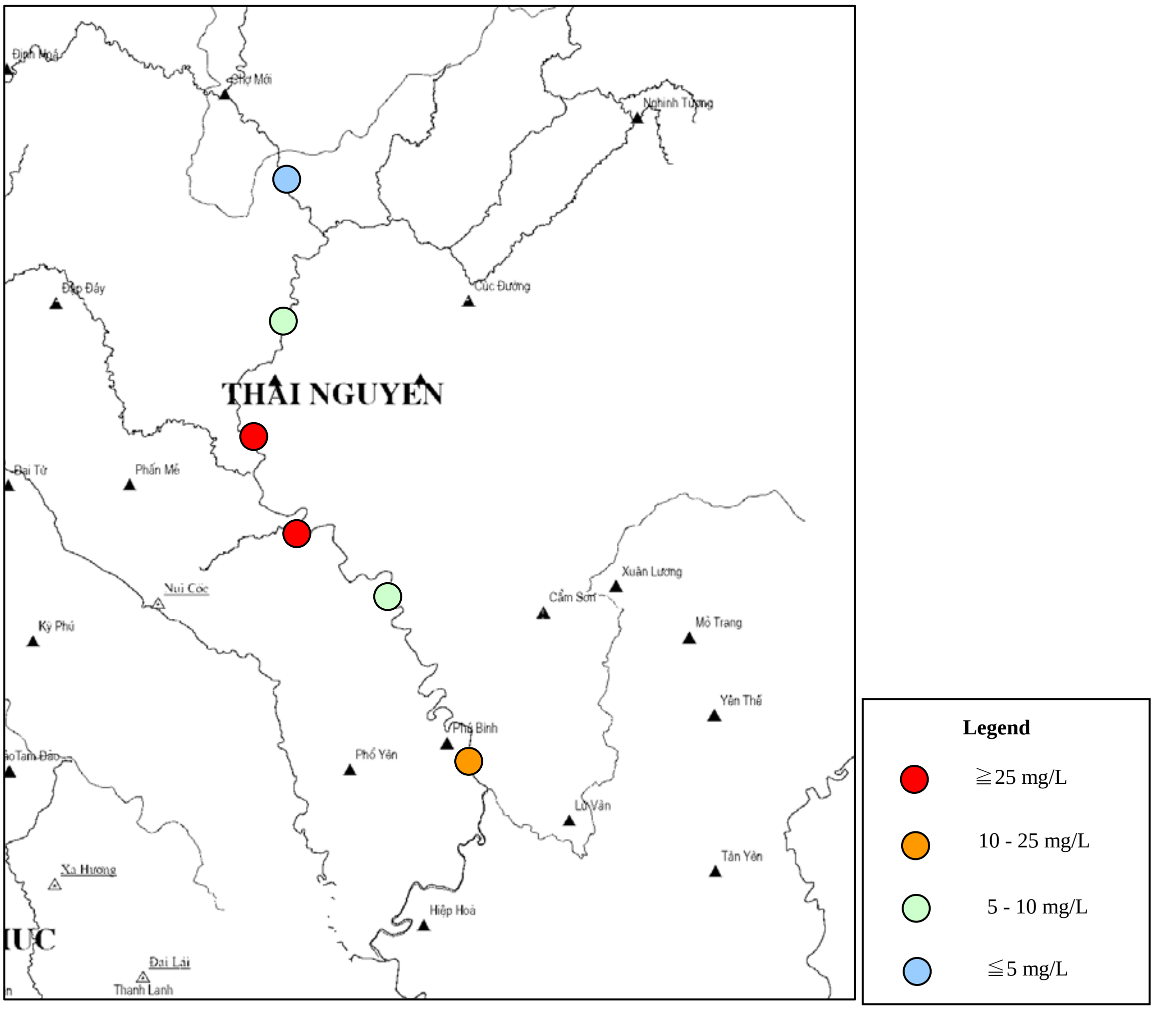


Figure 6.2-2 Example of Evaluation of Compliance with Water Quality Standard (Using a Map)

6.2.2 Understanding and Checking the Impacts of Contaminants Released from Pollutant Sources

(1) Comparing between Upstream and Downstream Locations

The effects on river concentrations by contaminants released from pollutant sources can be identified by comparison between data from upstream downstream stations as shown in Figure 5.1-3. When the water quality downstream is significantly lower than the upstream water quality, an impact due to contaminants released from pollutant sources located between the two sampling stations can be confirmed.

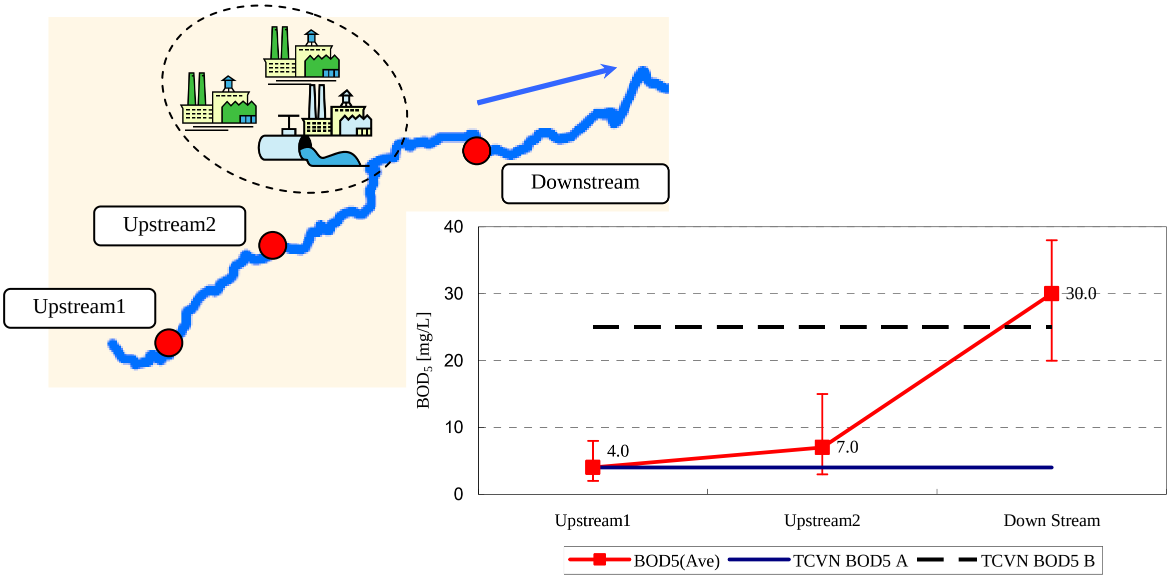


Figure 6.2-3 Impacts of Contaminants Released from Pollutant Sources (Comparing with Data of Upstream and Downstream)

(2) Comparing with Past Trend Data

The impacts of contaminants released from pollutant sources can be evaluated by comparing the present data with past data (e.g. before and after development of industrial park) as shown in Figure 6.2-4. Assuming that there is no reason to believe that the water quality upstream of the industrial park has changed since the development of the park, then changes in water quality downstream would indicate a probable impact resulting from the discharge of pollutants from the industrial park.

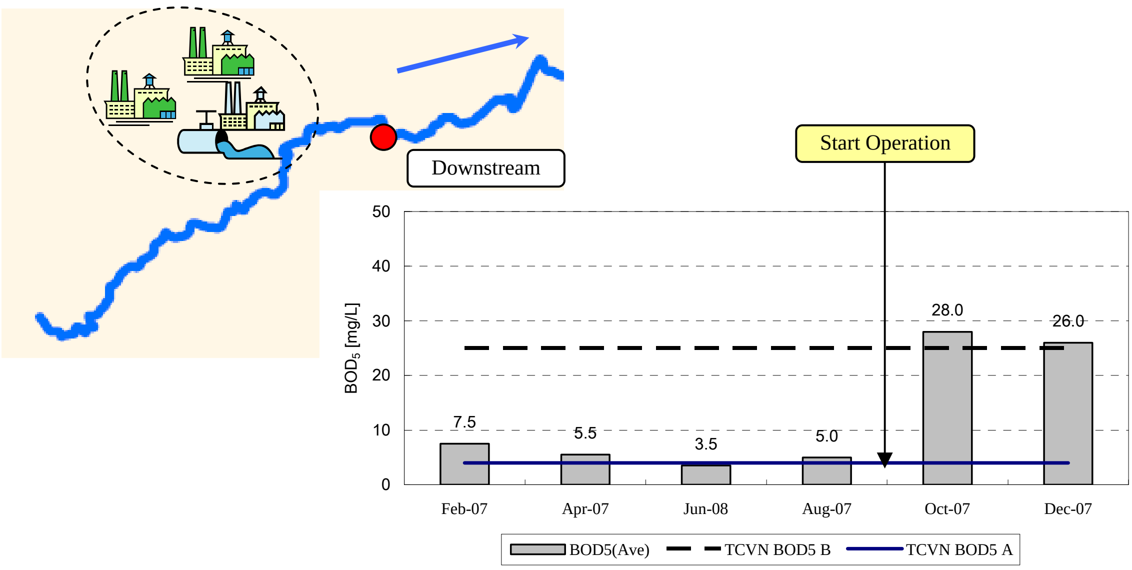


Figure 6.2-4 Impacts of Contaminants Released from Pollutant Sources (Comparing with Past Trend Data)

6.2.3 Understanding State of Water Quality as Baseline (Regional Typical Water Quality)

The water quality baseline is defined by the measured water quality at sampling stations which are representative of the area for which the base line is required. Where there is significant seasonality the data must be collected at time that reflect the seasonality. If the baseline is to be used to represent a clean condition then data that obscure the baseline condition, such as data collected from areas that are influenced by pollution sources should be excluded. An example is shown in Figure 6.2-5.

However if the intention is to use the baseline to assess the impact of a new pollution source into an area in which there existing pollution sources then these should be included in the definition of the baseline condition.

Furthermore, in case of considering baseline water quality in a sub-basin, the sampling points located before confluence point with main stream in each sub-stream should be selected and described.

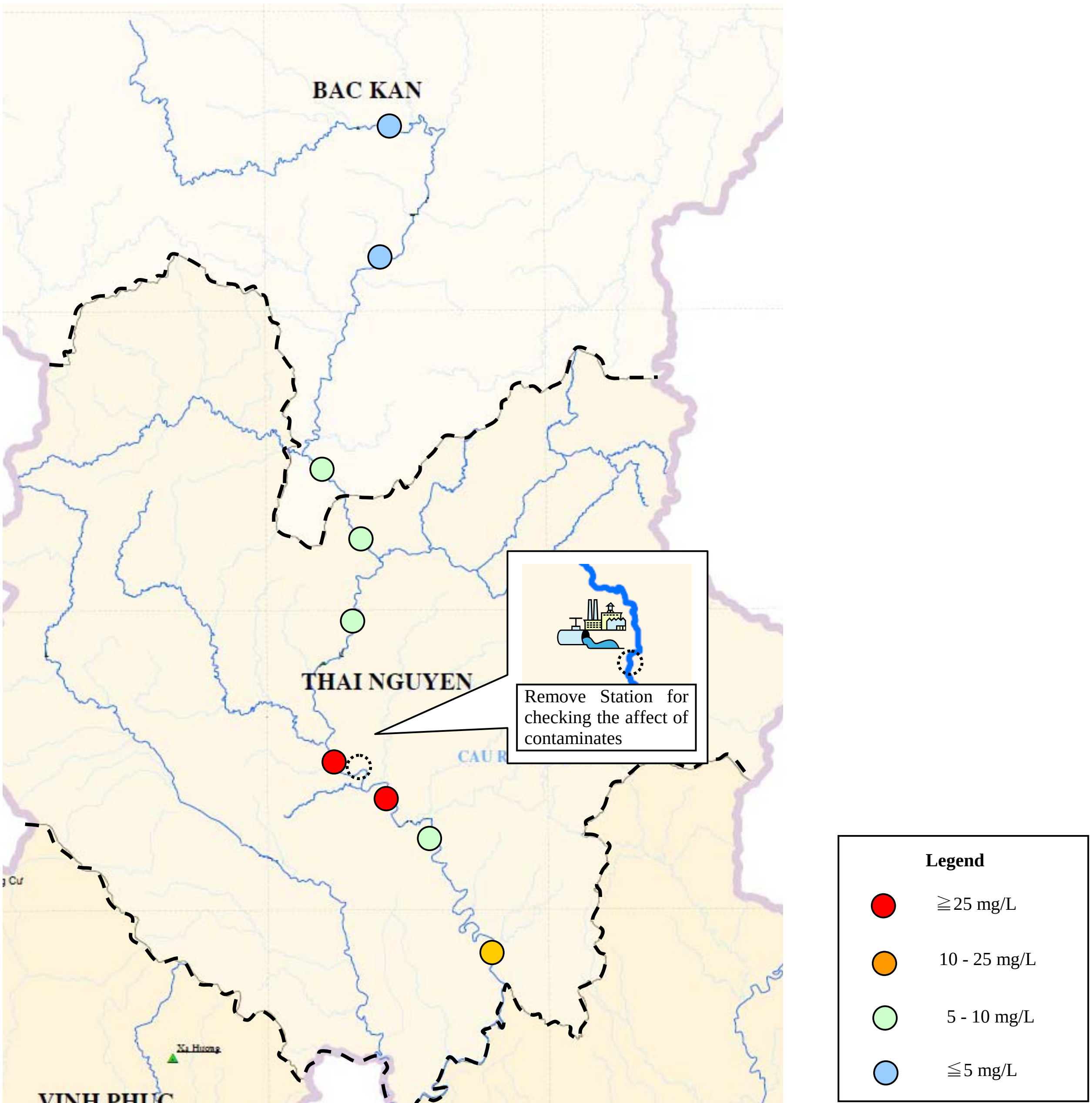


Figure 6.2-5 Understanding State of Water Quality as Baseline (Main Stream of Cau River)

6.2.4 Identifying the Serious Pollution Source (Critical Area) within the River Basin (Longitudinal Analysis)

Serious pollution sources within river basin can be identified by examining the longitudinal changes in water quality. In doing this the locations of any known tributaries and discharges into the main river channel should be identified on the independent axis, in this case distance, axis of the graph. Figure 6.2-6 shows an example of identifying the serious pollution source by using a graph.

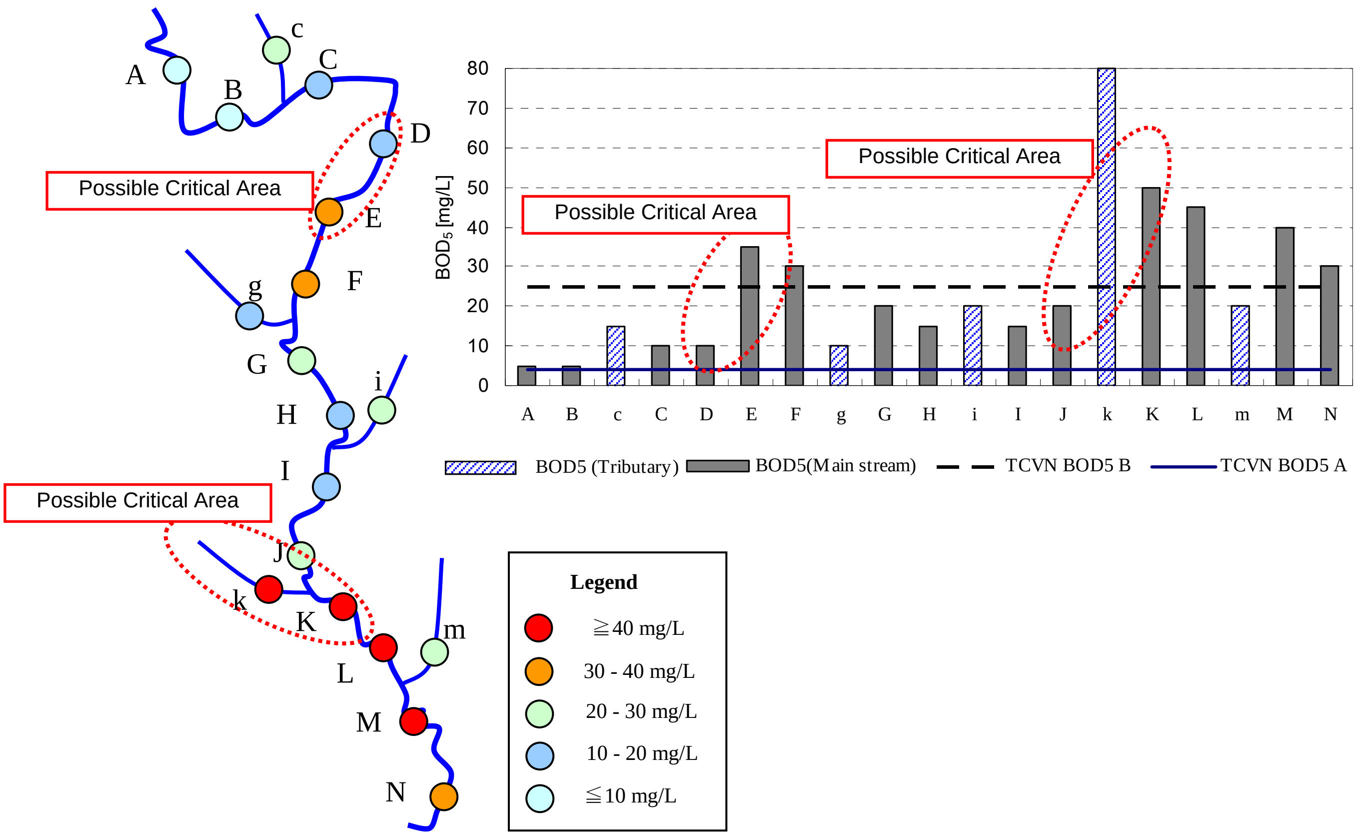


Figure 6.2-6 Identifying the Serious Pollution Sources (Critical Area) within the River Basin

6.2.5 Evaluating Effectiveness of Measures for Water Quality Conservation from Previous Trend and by Monitor its Effectiveness (Historical Trend Analysis)

The effectiveness of a water quality control measure or regulation can be evaluated by comparing the water quality trend before and after implementation of the measure.

Figure 6.2-7 and Figure 6.2-8 show an example of effect of water quality control measure by using a graph.

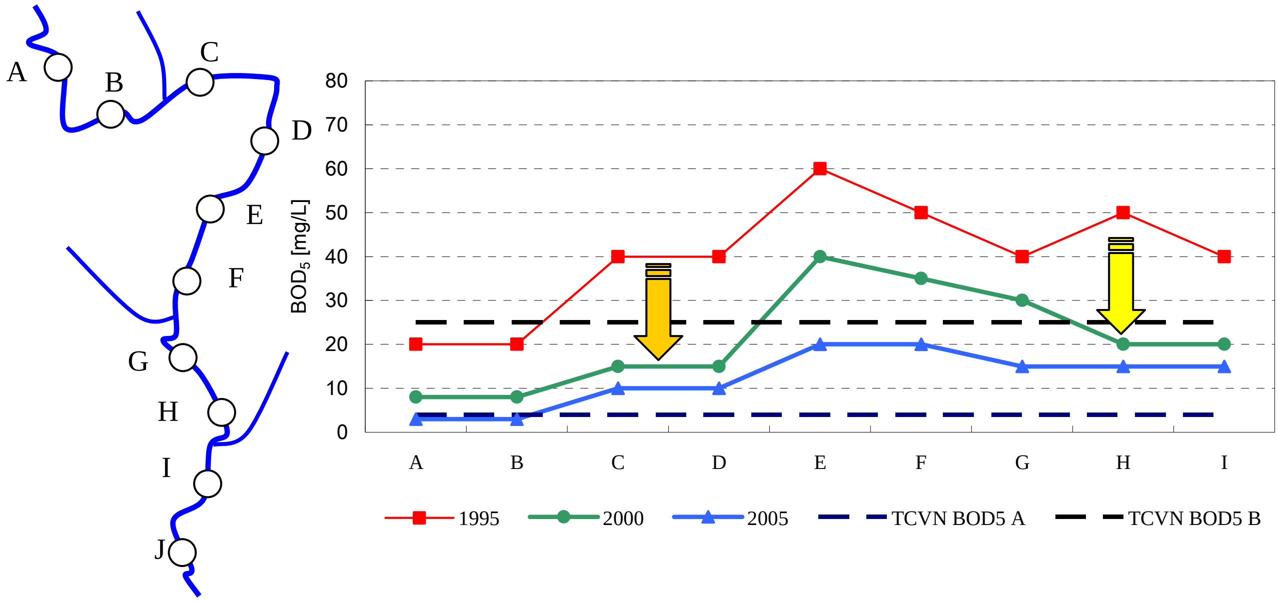


Figure 6.2-7 Effectiveness of Water Quality Conservation by Using a Graph (Comparing with Past Trend of Water Quality Level)

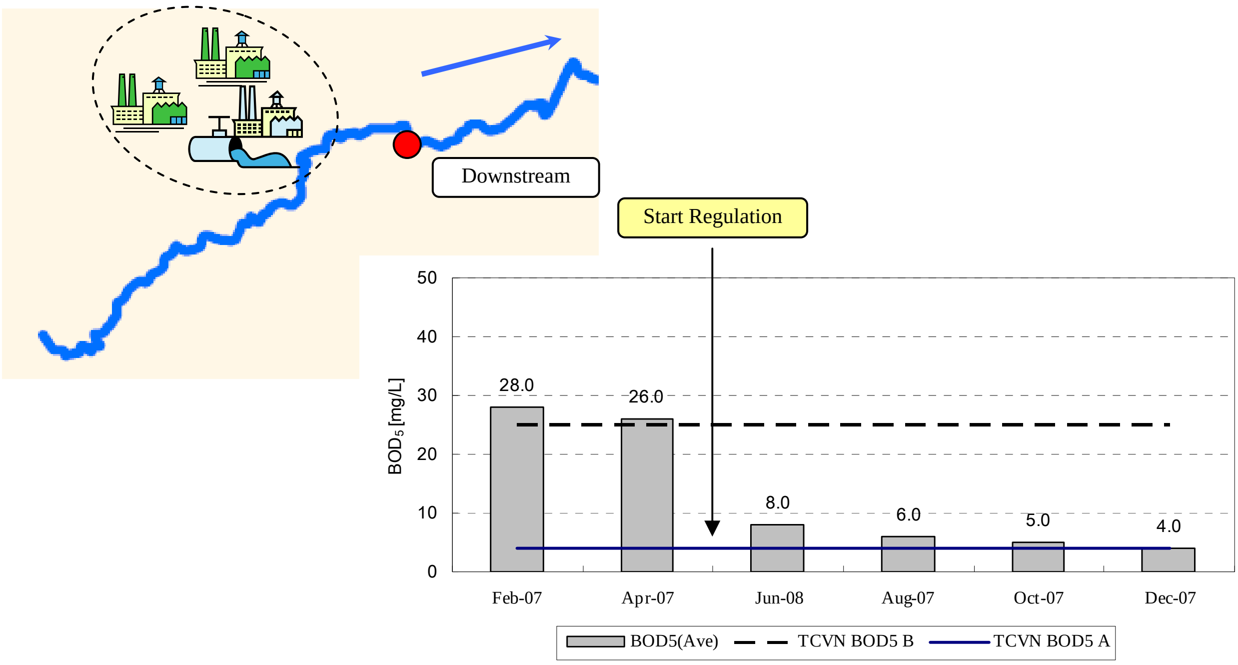
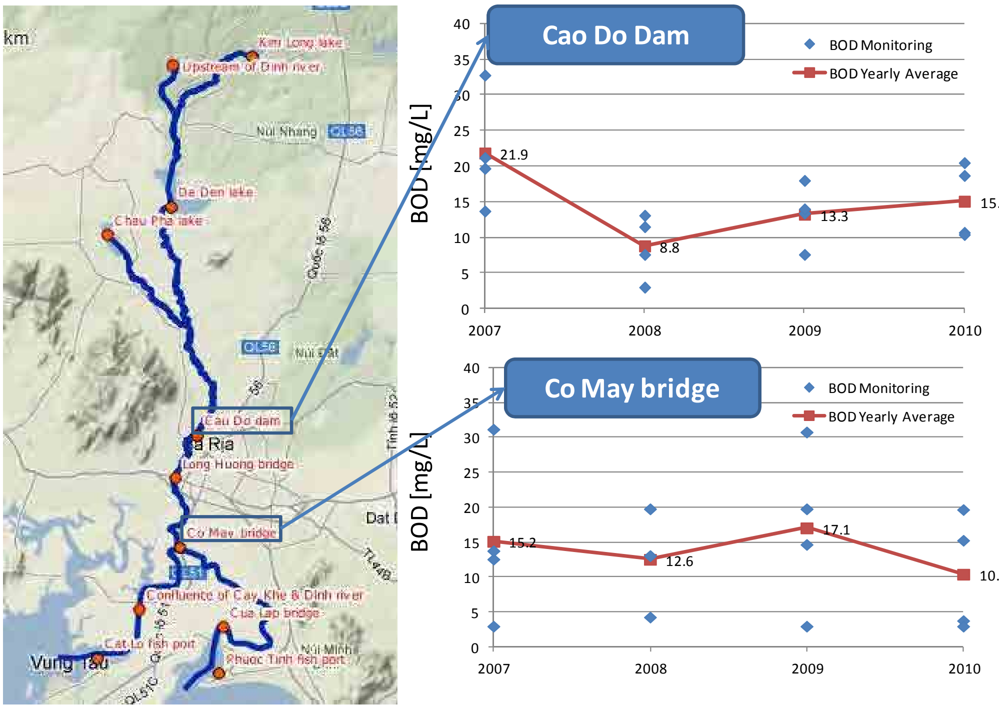


Figure 6.2-8 Effectiveness of Water Quality Conservation by Using a Graph (Comparing with before and after Installation of Pollution Control Regulation)

Figure 6.2-9 shows four years historical trend at representative monitoring points of the Dinh River in Ba Ria-Vung Tau Province. It is difficult to establish a clear trend of water quality change based on data collected over a four year period. Most DONREs have started water quality monitoring in the middle of the last decade, and it is frequently necessary to have carried out long-term monitoring continuously to be able to demonstrate a clear trend of water quality change.

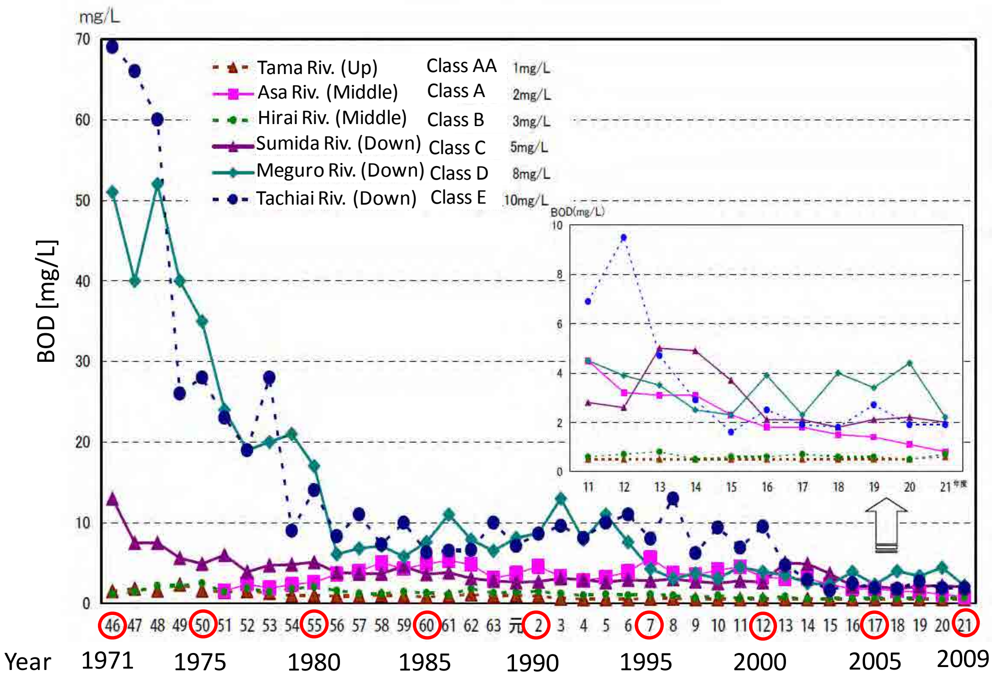


Source：JET quoted from Monitoring Report of BRVT DONRE

Figure 6.2-9 Four Years Historical Water Quality Trend of Dinh River in BRVT (BOD, Cao Do Dam and Co May Bridge)

Figure 6.2-10 shows monitoring data in Tokyo Metropolitan City in the past 30 years, which clearly show long-term improvement of water quality in the Meguro and Tachai Rivers where there between the years 1971 and 1980 there was a clear decline in BOD concentration after which time the concentrations became more stable and only slightly higher than the other four rivers. Data for the ten year period 1975-1985 would have been sufficient to demonstrate the transition between the period of declining concentration and the period of maintained low concentration.

A CuSum test would have identified the transition or hinge point around 1980/81 which would have allowed the data set to be split into two sub-sets whose BOD concentrations could have been compared using a t-test for unequal variances.



Source：Environmental Department of Tokyo Metropolitan Government

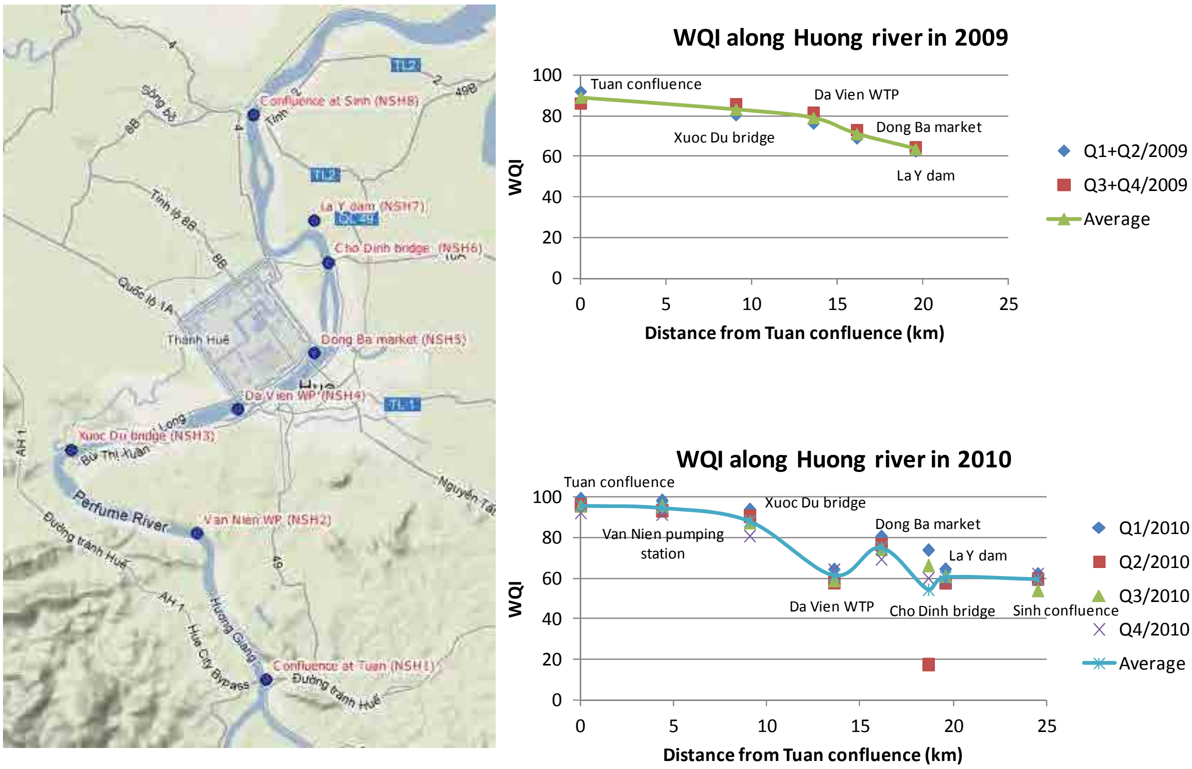
Figure 6.2-10 Lon-term Historical Water Quality Trend (BOD, Representative Points in Tokyo City)

6.3 Adoption of Water Quality Index in Surface Water Area

The VEA Decision No. 879/QD-TCMT Guideline on Calculation of Water Quality Index (WQI) of Surface Water Environmental Monitoring was issued in July 2011. It was appropriate therefore for JET to introduce the outline of the decision, the use of WQI methods in other countries. As examples of the application of the index, WQI values calculation using data from Vietnamese rivers were presented following the guidance handout prepared by CEM/VEA.

It became clear that monitoring activities of the target DONREs did not cover all the determinands that are required to calculate the WQI. Theses are BOD_5, COD, $N\text{-}NH_4^+$, $P\text{-}PO_4$, Turbidity, TSS, Coliform, DO, pH, and Temperature. In response, DONRE will add some monitoring determinands for calculation of WQI in the target rivers.

Figure 6.3-1 shows an example of the application of the WQI to the Houng River in TT-HUE. The WQI score decreases from upstream to downstream because of the domestic wastewater discharges from urban area into the river.



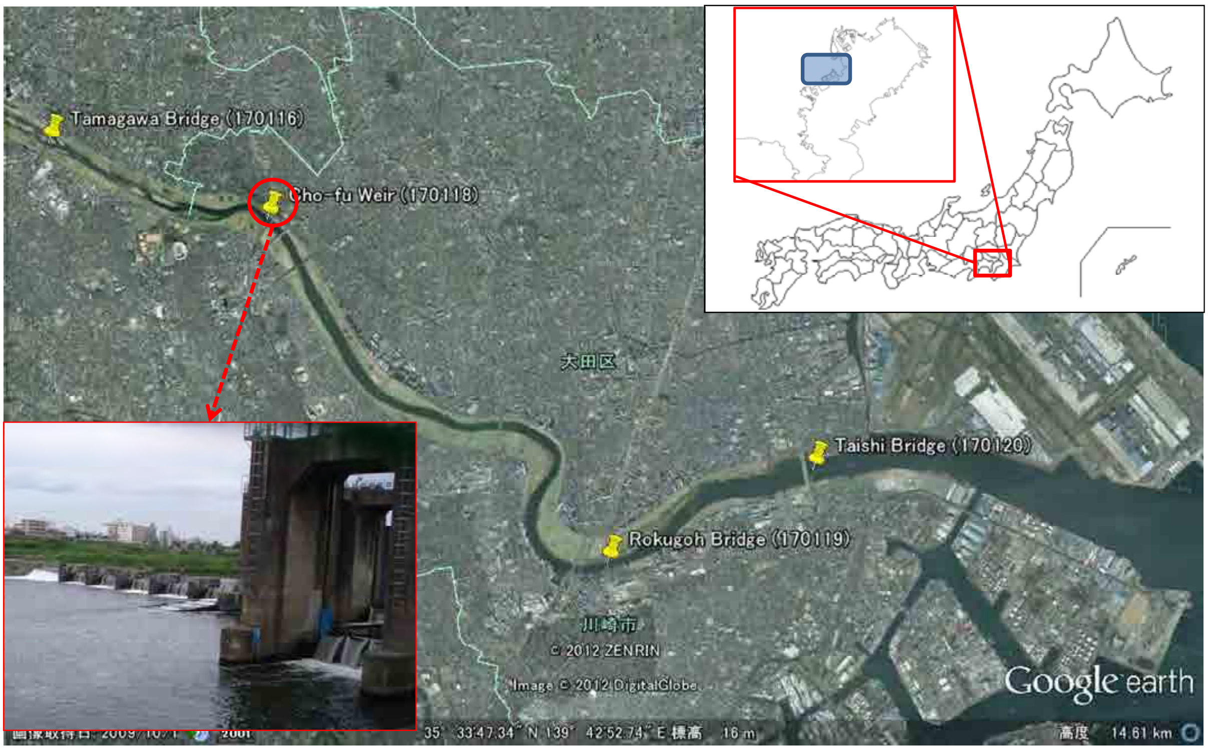
Source：JET quoted from Monitoring Report of TT-HUE DONRE

Figure 6.3-1 Longitudinal WQI Trend of Houng River in TT-HUE

6.4 Basic Data Analysis in Brackish Water Area

Most of the rivers in the target provinces except those in Ha Noi City are partially located in a tidal zone. Consequently water quality in the lower reaches of these rivers fluctuates in response to tidal state. To illustrate typical features of water quality in tidal zone, four monitoring stations in the mouth of Tama River reaching to Tokyo Bay were picked and their location are shown in Figure 6.4-1.

The area from the river mouth to Cho-fu Weir is affected by seawater, while the area upstream of the weir is not because the weir prevents sea water reaching an intake which is used as a source for drinking water. Consequently the two monitoring stations, Taishi Bridge (Code: 170120) and Rokugoh Bridge (Code: 170119), are influenced by sea water.

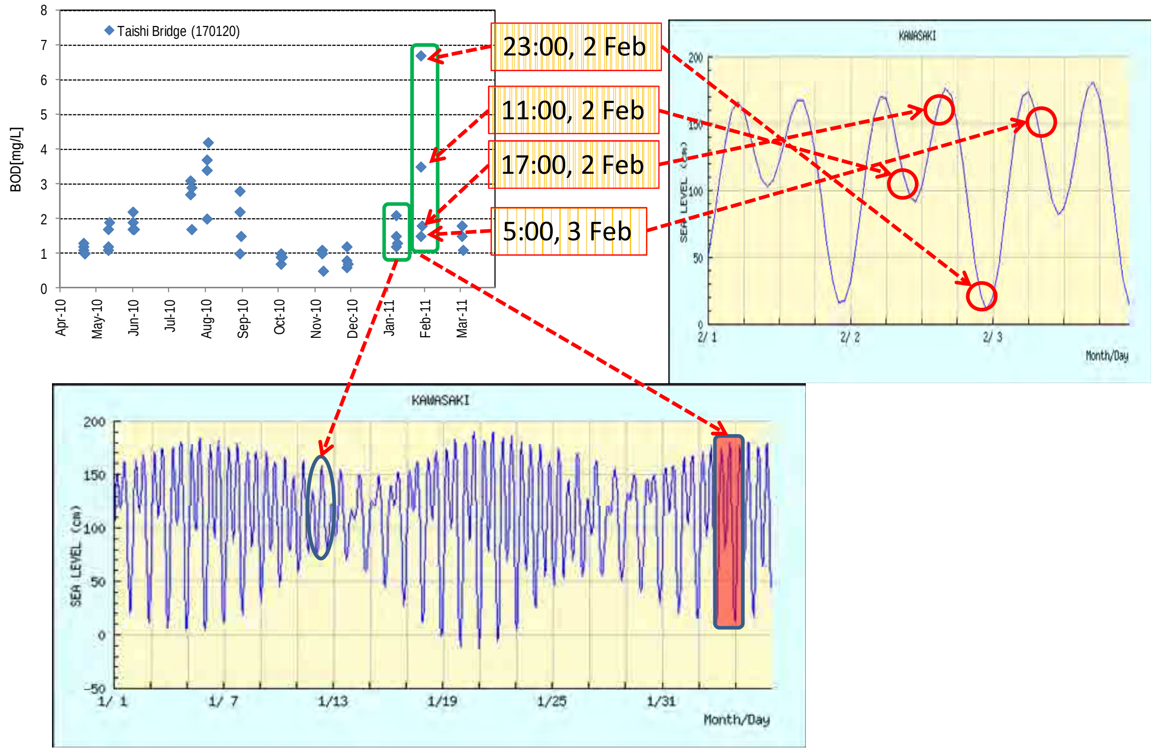


Source: JET quoted from database in Environmental Department of Tokyo Metropolitan Government and Google Earth

Figure 6.4-1 BOD Concentration in the Mouth of Tama River Reaching to Tokyo Bay and Sea Levels near the Monitoring Station in Tokyo Bay

Figure 6.4-2 shows BOD concentrations for the JFY 2010at Taishi Bridge monitoring station located in the mouth of Tama River which flows into Tokyo Bay. Water quality is measured monthly when four samples are taken at 6-hour intervals Also shown are the sea levels near the monitoring station from January to February in 2011 which show quite clearly the existence of a strong spring-neap cycle together with typical asymmetric semi-diurnal tides. Details of tide levels for the first four days of February are shown in detail

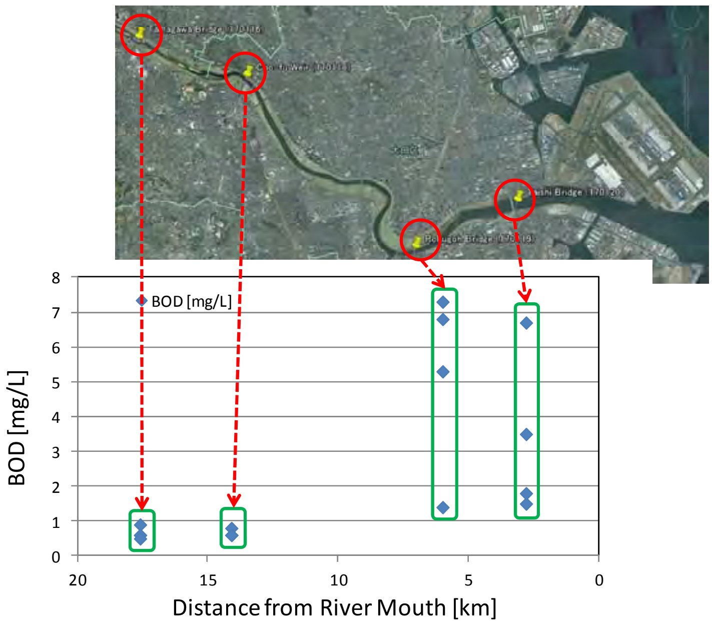
The range of concentration of BOD on the monitoring day in January 2011 is smaller than that in February. This is because the tides on the sampling day in January 2011 neap tide and those in February 2011 were spring tides. In addition it would appear that BOD concentrations around the low tide (at 11:00 and 23:00 on February 2011) are higher than those from the high tide period due to organic matter in bed being disturbed and brought to the surface.



Source: JET quoted from database in Environmental Department of Tokyo Metropolitan Government and database in Japan Meteorological Agency

Figure 6.4-2 BOD Concentration in the Mouth of Tama River Reaching to Tokyo Bay and Sea Levels near the Monitoring Station in Tokyo Bay

Figure 6.4-3 shows the longitudinal variation of BOD concentration in the downstream area of Tama River at the same day of monitoring in February 2011 around spring tide. It is evident that BOD concentrations at Chou-fu Bridge (Code: 170118) and Tamagawa Bridge (Code: 170116), the two monitoring stations upstream of Cho-fu weir showed a smaller fluctuation when compared with those in the tidal zone downstream of the weir.



Source: JET quoted from database in Environmental Department of Tokyo Metropolitan Government and Google Earth

Figure 6.4-3 Longitudinal Trend of BOD Concentration in the Downstream Area of Tama River (in February 2011)

6.5 Physico-Chemical and Biological Processes in the Environment

6.5.1 Introduction

In order to be able to interpret and explain changes in water quality it is necessary to understand the processes that are taking place as the water travels along the river. These can be divided into

- Conservation of mass
- Physico-chemical constraints and interactions
- Biological processes

Important processes within these categories are described below. Additional graphics relating to the topic can be found in a copy of the training presentation ‘Rivers and Pollutants. Has the concentration changed, and if so why?’ in Appendix 4.

6.5.2 Conservation of Mass

The conservation of mass concept can be applied to any pollutant being discharged into a river unless it is subject to an immediate chemical or physic-chemical change within the initial mixing zone. Examples of such a change would be:

- the rapid uptake of oxygen from the atmosphere by following the discharge of an effluent with a very low dissolved oxygen concentration
- precipitation of metal oxides in an effluent containing high concentrations of metals in a soluble reduced state, eg iron and manganese in anoxic water
- precipitation of elemental sulphur from an effluent containing dissolved hydrogen sulphide.

With the exception of conditions such as those described above, pollutant concentrations downstream of a confluence of two rivers or down stream of a discharge can be calculated using the following equation.

Since $$Q_d C_d = Q_u C_u + Q_e C_e$$ Eqn.1

and $$Q_d = Q_u + Q_e$$ Eqn. 2

then $$C_d = \frac{Q_u C_u + Q_e C_e}{Q_u + C_e}$$ Eqn. 3

Where:
Q_d = Flow downstream of the confluence or discharge (m^3/s)
C_d = Concentration downstream of the confluence or discharge (mg/l)
Q_u = Flow in the main channel up stream of the confluence or discharge (m^3/s)
C_u = Concentration in the main channel upstream of the confluence or discharge (mg/l)
Q_e = Flow in the effluent channel or tributary (m^3/s)
C_e = Concentration in the effluent channel or tributary (mg/l).

Such type of calculations are not limited to the tributary or effluent discharge situation. Calculations of mass flow Q×C calculations, usually expressed as g/s for small rivers and kg/s in larger rivers, at all flow monitoring stations along the length of a river are a useful check on the consistency of the water quality data set.

6.5.3 Dissolved Oxygen

It is usual to express environmental standards for dissolved oxygen in terms of concentration, usually as mg/l. The reason for this is that it is the concentration in the surrounding which regulates the ability for fish, amphibians and aquatic invertebrates to take up oxygen from the water.

However when evaluating the impact of oxygen consuming pollutants such as BOD it is how much the measured concentration is below the saturation concentration usually expressed at percent saturation (%sat).

The saturation concentration of oxygen in river water is controlled primarily by the water temperature, the lower the temperature the more oxygen will dissolve in the water. The following nomogram enables percentage saturation to be determined given that water temperature and concentration are known.

In the example shown in Figure 6-.5-1 the river water temperature was 24°C and measured dissolved oxygen concentration as 5.5 mg/l. A constructed index line or isopleth between the respective values on the temperature and concentration scales intersects the saturation scale at 64% saturation. Although the sample meets the QCVN of 4 mg/l the fact that the water only contains two-thirds of the amount of oxygen that it could carry at that temperature indicates that the river under stress.

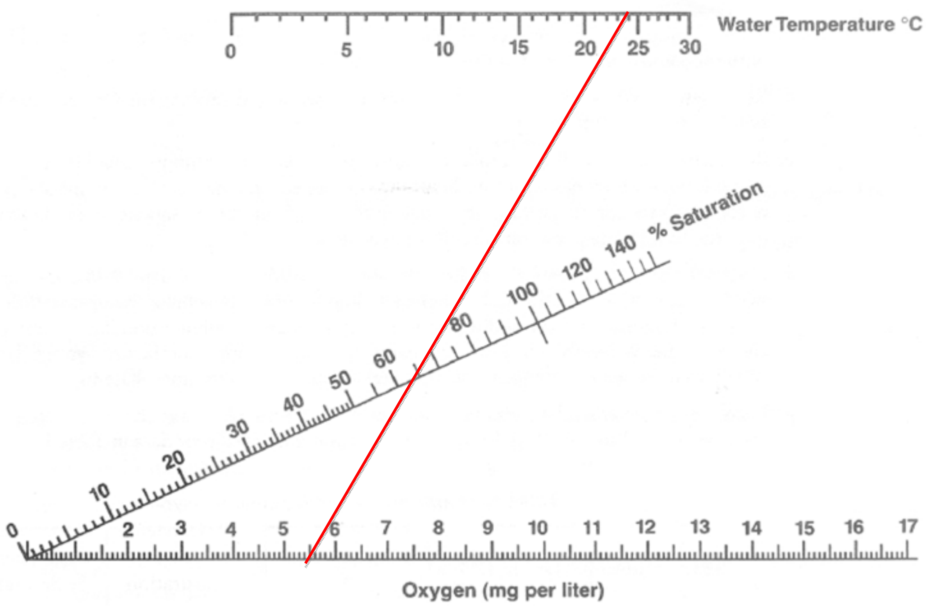


Figure 6.5-1 Oxygen Concentration, Saturation and Temperature Nomogram for Freshwater

The ability to express the concentration as %saturation is particularly valuable when comparing between seasons when a decrease in dissolved oxygen concentration of up to 2mg/l is not the result of pollution but simply the seasonal increase in water temperature and despite the decrease in concentration the water remained 100% saturated.

It is unusual for oxygen super-saturation to occur in the environment. During periods of very calm conditions and high solar radiation input photosynthetic activity by phytoplankton and submerged macrophytes will be high. Dissolved oxygen will accumulate in the water at a higher rate than it can diffuse into the atmosphere and consequently superstation concentrations, occasionally greater than 150% saturation, may occur. This situation is more likely to occur in a lake than in a river where turbulence will be higher and light penetration will be less than in a lake. Only in extreme cases will supersaturation be observed in marine conditions.

6.5.4 The Nitrogen Cycle

Nitrogen is a ubiquitous element being present as a gas in the atmosphere, and combined in a wide range of inorganic and organic compounds. Many of the inorganic forms are soluble in water and consequently are frequently present in fresh and marine waters above and below ground.

Nitrogen is cycled through pathways in the nitrogen cycle shown in Figure 6.5-2.

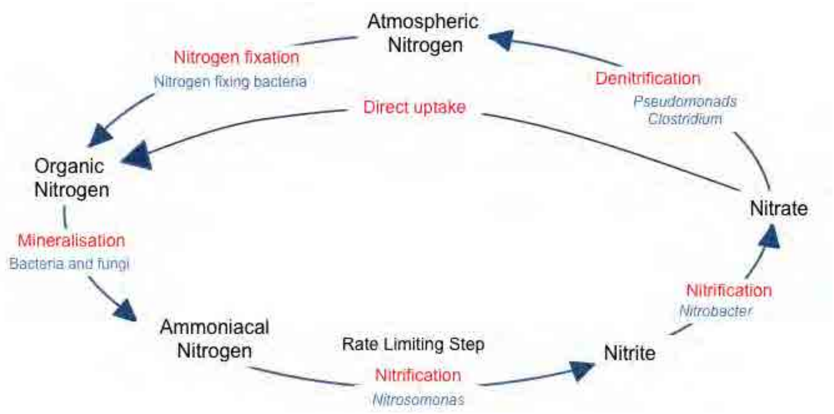


Figure 6.5-2. The Nitrogen Cycle

It is possible for almost all of the cycle to take place within the aquatic environment and so it is necessary to be aware of the cycle when interpreting water quality data. The driver for the cycle is primarily the discharge of organic and ammoniacal nitrogen into surface waters. This will originate from domestic sewage, industrial wastewaters (primarily food related industries), and from animal farm wastes. Inorganic nitrogen in the form of nitrate fertilizer will also contribute to the cycle.

It is important to remember that the cycle is anticlockwise in as much as organic nitrogen passes through ammoniacal nitrogen, nitrite to nitrate in that order. Given an adequate supply of oxygen in the water the rate limiting step is the nitrification of ammoniacal nitrogen to nitrate. Consequently nitrite should not accumulate in the river water and so should only be present in low concentrations.

Accumulation of nitrite may occur under low ambient dissolved oxygen concentrations or in the presence of toxic compounds which inhibit the nitrobacter mediated conversion of nitrite to nitrate[1].

The biologically mediated process of nitrification process requires oxygen to convert the ammoniacal nitrogen to nitrate. As such it contributes, to the much more inclusive biological oxygen demand. The conventional BOD measurement measure both carbonaceous and nitrogenous oxygen demand and so reflects the presence of both the utilization carbon based contaminants and the oxidation of ammonia.

It is the ammoniacal from of nitrogen which is of particular concern in terms of ecotoxicology. The ammoniacal nitrogen can exist in two forms; ionised ammonia NH_4^+ and un-ionised or free ammonia NH_3 and it is the latter form which is toxic to fish, amphibians and aquatic invertebrates. The two forms co-exist in an equilibrium. The principle determinant of the state of the equilibrium is the pH of the water. The unionized ammonia is the toxic form whose toxicity is increased at low dissolved oxygen concentrations.

Since knowledge of the pH of the water is significant in calculating the concentration of free ammonia in the water the measurement of the environmental pH is a critical measurement.

There are a number of polynomial equations available for calculating the proportion of the total ammoniacal ammonia that is present in the free form for typical environmental combinations of pH and temperature. Figure 6.5-3 can be used as an approximate guide as to the percentage of free ammonia.

[1] Halling-Sørensen, B. and S.E. Jorgensen. The Removal of Nitrogen Compounds from Wastewater. Studies in Environmental Science 54. Elsevier. 1993.

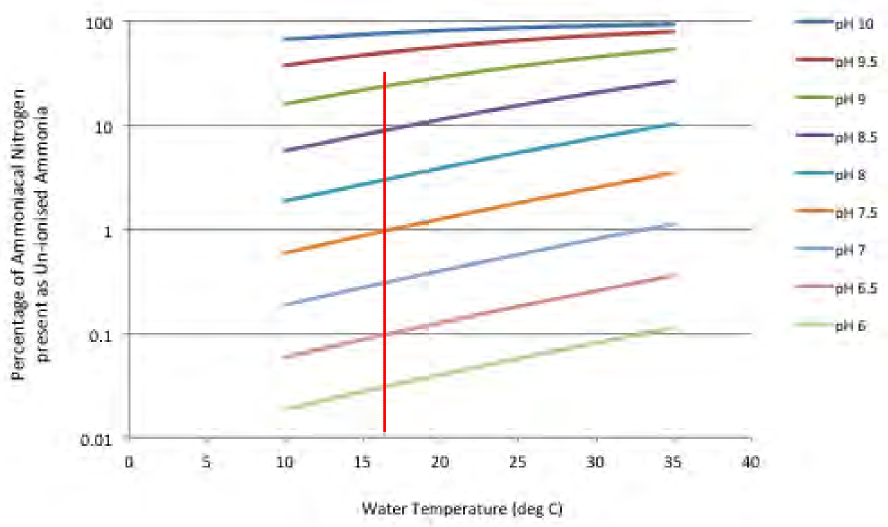


Figure 6.5-3 Relationship Between Percentage Free Ammonia and Water Temprature and pH

In the case above with water temperature of 25°C and pH 8.5, approximately 15% of the measured ammoniacal nitrogen will be present in the un-ionized ecotoxic form.

It is recommended that within the data base a column be place adjacent to the ammoniacal nitrogen column to contain the concentration present in the un-ionised form.

6.5.5 Biological Oxygen Demand

Biological Oxygen Demand (BOD) measures the uptake of oxygen from the water by microbes feeding on carbon based molecules and when oxidizing ammonical nitrogen. It is measured over a five day period, in the dark, at constant temperature. The test begins with the water fully saturated with oxygen which, for a measurement to be considered valid, is not allowed to fall below 2 mg/l. Almost perfect conditions for the microbes. Normally measurements of oxygen concentration are made at the beginning and end of the 5-day period by which time almost all of the BOD has been utilised. This gives no indication of the dynamics of the process. If measurements are made every day and the amount of BOD remaining at the end of each day calculated a curve similar to that shown in Figure 6.5-4 would be created.

The resulting curve, is known as a first order decay curve and can be described by the following equation.

$$BOD_t = BOD_0 exp(-k_1 t) \qquad \text{Eqn. 4}$$

Where

BOD_t = the BOD remaining after time t (mg/l)
BOD_0 = the initial BOD (mg/l)
k_1 = the rate coefficient (/d)
t = the time period (d)

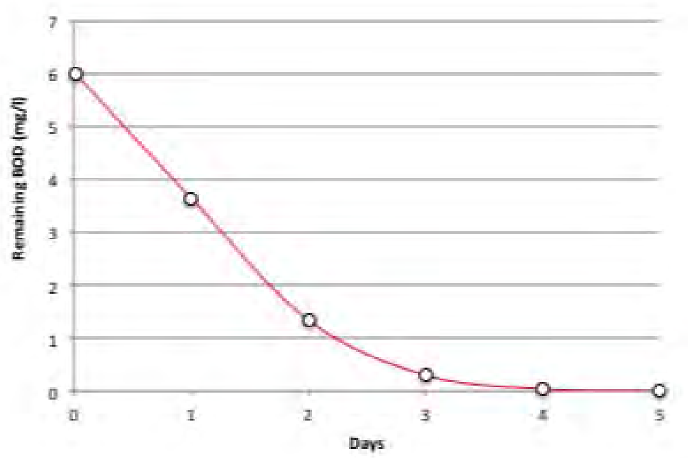


Figure 6.5-4 Decline in Remaining BOD over a 5-day Period

In this case the calculated k_1 value is 0.5. This would represent the optimal rate of utilization of the BOD under the optimal conditions. Values of k_1 measured in the field can be found in the range 0.5 to 0.05. The smaller the k_1 value the slower the utilization rate.

If the water speed is known at the time of sampling it is possible to convert the time axis to distance below the sampling point. Comparison of the remaining BOD vs distance curve with downstream concentrations will enable unusually low BOD concentrations to be identified and the causes sought.

The predictable decay in BOD downstream of a discharge together with the transfer of oxygen from the atmosphere to replace that utilized were brought together in the well known Streeter-Phelps equation and provides an explanation of the shape of the oxygen sag and recovery below wastewater outfalls with a high BOD content.

6.5.6 The Oxygen Sag and Recovery

The Streeter-Phelps equation combines the following process in an equation which predicts the decline and recovery of dissolved oxygen concentration together the decline in ammoniacal nitrogen and BOD. Originally developed to model a single discharge, it is possible to link the equations to simulate the effects of sequential discharges along a length of river. This is typical of many of the rivers in Viet Nam where the rivers receive discharges from many sources.

The simplest from of the model consists of two terms representing the consumption dissolved oxygen created by the BOD and the uptake of oxygen from the atmosphere driven by the difference between the oxygen concentration in the river and the saturation concentration.

The processes in the model are additive and so can be combined into a single equation which is shown below together with a description of the terms.

$$D = \frac{k_1 L_a}{k_1 - k_2}\left(\exp^{-k_1 t} - \exp^{-k_2 t}\right) + D_a \exp^{-k_2 t} \qquad \text{Eqn. 5}$$

Where

- D = the dissolved oxygen saturation deficit (mg/l)
- k_1 = the BOD deoxygenation rate (/d)
- k_2 = the reaeration rate (/d)
- L_a = the initial oxygen demand of organic matter in the water (mg/l)

D_a = the initial oxygen deficit (mg/l)
t = the elapsed time, usually (d)

Running the model for the following conditions:

- an outfall giving a fully mixed in-river BOD_5 of 9.5mg/l
- initial dissolved oxygen concentration of 6 mg/l
- river water temperature 23°C
- average water depth 2.5m and
- average river speed 0.2 m/s
- k_2 using Churchill TVA sub-model (temperature corrected)
- k_1 0.7 at 20°C (corrected for local temperature)

generates the output shown in Figure 6.5-5

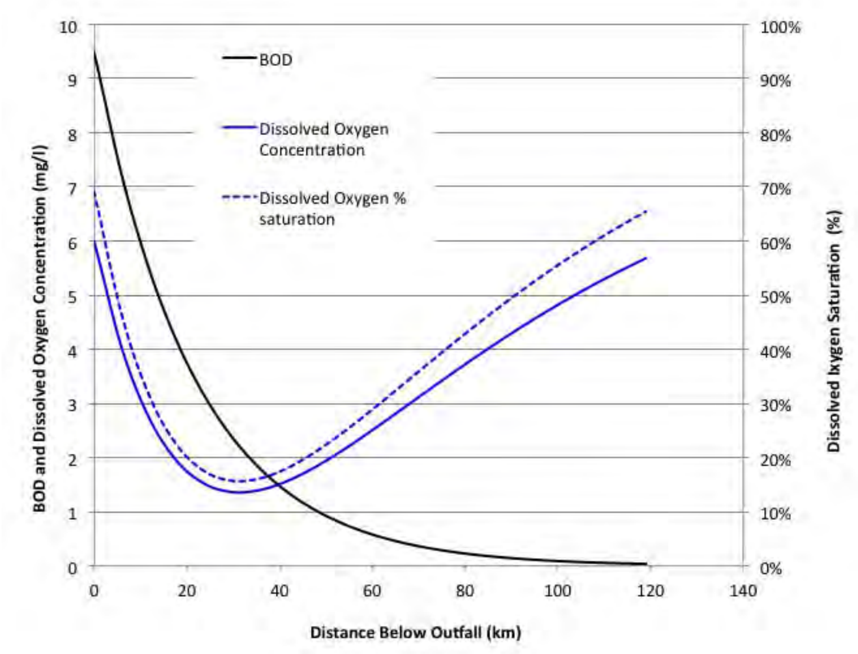


Figure 6.5-5 Output from a Two Component Streeter-Phelps Model Showing Downstream Oxygen Sag and Recovery

This shows the classical steep dissolved oxygen drop followed by a more shallow uptake of oxygen from the atmosphere. The dissolved oxygen minimum of 1.4 mg/l occurs approximately 30km below the outfall.

The application of a simple two process model which can be run as a simple Excel spreadsheet provides a valuable learning tool to understand how different factors affects the way that a BOD discharge influences dissolved oxygen concentrations in a river.

The Streeter-Phelps model can be extended to include more terms which take account of additional processes in the river. To demonstrate the relationship between BOD, dissolved oxygen, ammoniacal nitrogen and nitrate nitrogen the model was run with the full set of six processes.

The processes which can be modeled are:

- Initial dissolved oxygen deficit
- Oxygen consumption through carbonaceous BOD

- Oxygen consumption through nitrogenous BOD
- Net primary production
- Benthic and sediment consumption
- Background deficit

The example in Figure 6.5-6 is taken from a temperate climate river receiving an effluent in which the carbonaceous and nitrogenous BOD are approximately equal and which ahs an initially high nitrate-nitrogen concentration resulting from run off from fertilized arable land in the upstream area.

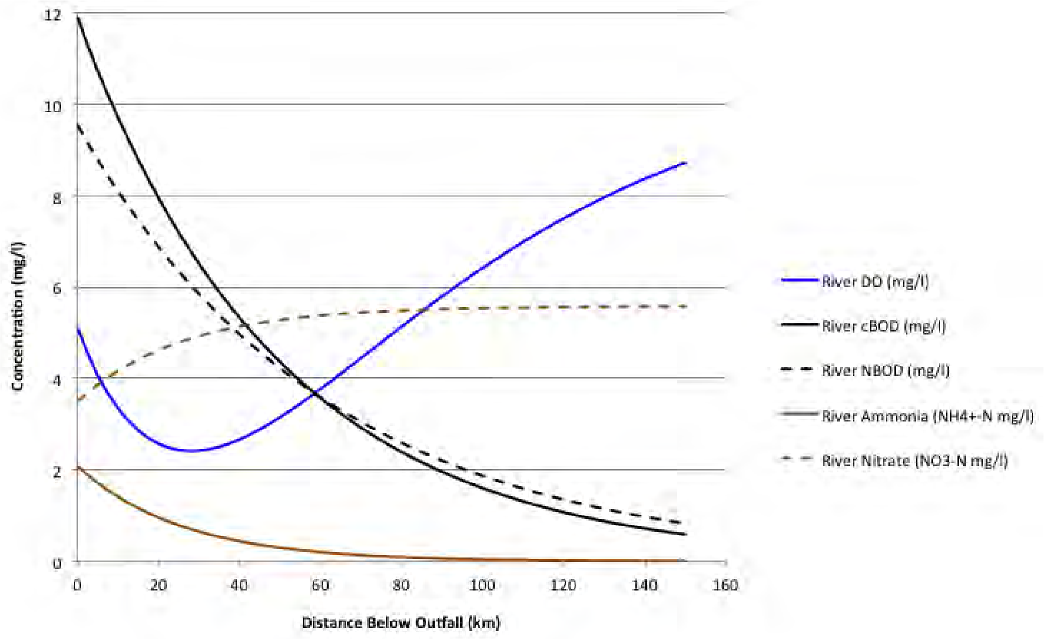


Figure 6.5-6. Output from a Full Streeter-Phelps Model Showing Downstream Oxygen Sag and Recovery, BOD Decline and Increasing Oxidised Nitrogen Concentrations.

6.5.7 Total Coliforms, Faecal Coliforms and E. coli.

There are many micro-organisms present in surface waters that can give rise to human health problems. These organisms include:

- Bacteria
- Viruses
- Protozoa and
- Parasites

The detection, identification and quantification of the last three in the list is a difficult and time consuming activity whereas the processes for bacteria can be more easily carried out.

Therefore the presence of specific groups and sub-groups of bacteria as used as an indicator of the potential presence those pathogens more difficult to detect and quantify.

The measurement of total coliforms is a relatively straight forward procedure to carry out and serves as a general indicator of the presence of bacterial contamination of a water course and the potential for infective pathogens to be present.

The coliform group of bacteria are found in many areas of the environment and can be found in rivers which are not receiving pollution from sources containing human pathogens.

The following table summarises the different sub-groups that are contained in the coliform category.

Table 6.5-1 Sub-Groups Contained in the Coliform Category

Sub Group	Occurrence in the environment	Route into surface waters	Human health significance
Citrobacter	Found almost everywhere in the environment. Can be found in the human intestine	Run off, raw sewage and effluent from sewage treatment works	Rarely the cause of illness
Hafnia	Commensal in the human gastro –intestinal tract	Raw sewage and effluent from sewage treatment works.	Resistant to many antibiotics. May cause infections in immuno-compromised patients.
Klebsiella	Common in vegetation, soil and surface waters. Transient in the intestines of humans and other animals	Raw sewage and effluent from sewage treatment works and run off from farms.	Opportunistic pathogen
Serratia	S. marcescens is the most common species of Serratia in the environment. Found in damp conditions.	Run off, wastewater containing input from hospitals.	Opportunistic pathogen, frequently causing infections in hospitals (nosocomial)
Enterococcus	Normal part of the intestinal flora of humans and other mammals. Includes *E. faecalis*, previously known as *Streptococcus faecalis*	Raw sewage and effluent from sewage works.	Some species are pathogenic and becoming a nosocomial problem due to increasing resistance to antibiotics.
E.coli	*Escherischia coli* is a common component of the lower intestine of human and other mammals.	Raw sewage and effluent from sewage treatment works and run off from farms.	Virulent strains of *E. coli* can cause gastroenteritis, urinary tract infections, and neonatal meningitis. In rarer cases, virulent strains are also responsible for hemolytic-uremic syndrome, peritonitis, mastitis, septicemia and Gram-negative pneumonia. Some of these illnesses may be life threatening.

While the presence of high numbers of coliforms in surface waters may be an indicator increases, particularly following a period of heavy rain may be due to open ground run off rather than a sewage related source.

The measurement of *E. faecalis* (faecal streptococcus) and *E. coli* provides a more reliable indicator of the specific presence of faecal contamination and hence the presence of the other viral, protozoan and parasitic agents of potentially life threatening illnesses.

It is therefore recommended that if budgets are limited the more specific indicators of faecal contamination are measured rather than the more general total coliforms.

The environmental survival period of pathogens causing severe illnesses in humans is relatively short. Their natural habitat in a human intestine is dark, warm (37°C), low salinity and high in nutrients. When in river their survival time is short and they will die-off. The rate at which they decay follows a first order decay model, similar to that of BOD.

$$C_t = C_0 \exp^{-k_b t} \qquad \text{Eqn. 6}$$

Where :

C_t = Concentration of bacteria after time period *t* (No/100ml)
C_0 = Initial concentration (No/100ml)

K_b = Bacterial decay constant (/d)
t = Time period (days)

Different types of pathogen die off at different rates in the environment. Figure 6-5.7 shows the die off of three examples of bacteria, a virus and a parasite (Giardia). Initial concentrations are those that might be found immediately downstream of a domestic sewage outfall and the decay constants are typical values for water at 20°C.

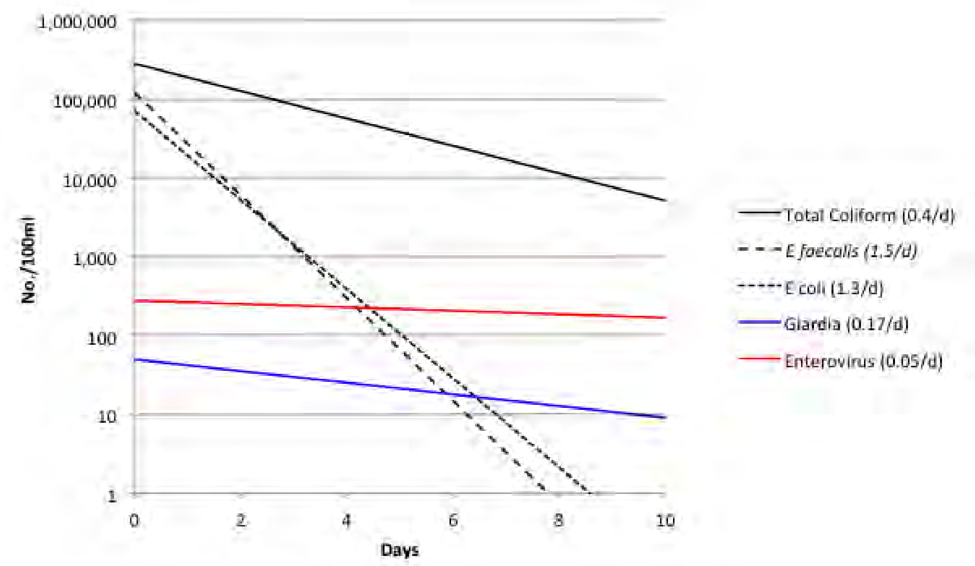


Figure 6-5.7 Example of Die-off for Sewage Related Micro-organisms

The figure clearly shows:

- the rapid die off of *E. coli and E. faecalis,* both normally found in the intestine of mammals,
- the slower die off of Total Coliforms since a proportion of the total coliforms are bacteria that naturally occur in external environment and so will survive longer.
- the slow die off of parasite Giardia which although normally living in the mammal intestine but under adverse conditions will form a resistant cyst
- the slow die off of the hepatitis virus due the protective outer capsid which protects the DNA from damage.

CHAPTER 7 REPORT PREPARATION

7.1 Introduction

The reports issued by the environmental monitoring sections of the DONRE form the interface between them and the senior staff of the DONRE, members of the PPC and staff in other Departments and Ministries. For some the report may be the only ‘contact’ between the two and so the report will be seen to reflect the quality of the staff in the section and the quality of the work that they carry out.

The preparation of a report is of equal importance to all of the other work carried out by the section and should not be regarded as a mundane task. The report should be regarded as the showcase of the section’s work and capability.

The purpose of a report is to inform the reader about a subject in which they have an interest and to that end it is important that the writers of reports understand who is the reader and what do they want to learn about by reading the report. A report will generally consist of text, tables figures etc. The structure of the report, the layout of the text and the presentation of information in the tables and figures determines how well the information can be understood by the reader.

There are three key elements to prepare environmental monitoring report as follows;

i. Identifying the purpose of the report and the requirements of the reader,
ii. The material to be included in the report and the report should be structured, and
iii. The style and presentation of text, tables and figures.

A set of guidelines, named “Guidelines for Writing Environmental Monitoring Reports”, covering the above three key elements of report preparation was prepared for daily works of monitoring sections of the DONRE. The set of guidelines is attached included in Appendix 4 of this handbook.

The following sections of this chapter outline the contents of the guidelines.

7.2 The Purpose and The Reader

(1) The Purpose
Reports can be divided into three basic types:

1) Factual
2) Instructional
3) Leading

The characteristics of the three different types of report can be summarized as follows:

Factual reports are designed to provide information and are a statement of facts to give the reader an accurate record of events that have occurred or measurements that have been made. In this case summarization of data, the calculation of basic statistics and whether environmental standards were exceeded are facts. Most of the reports to be written by the staff of the environmental monitoring section will fall into this category.

Instructional reports explain what is to be done when some change is introduced to an existing way of carrying out a task. Laboratory Standard Operating Procedures (SOP) would fall into this category.

Leading reports are used to persuade the reader to make a decision with regard to taking an action that is being proposed. These are specialized reports and would include requests to purchase laboratory equipment or to propose more effective implementation of pollution prevention measures.

(2) The Reader
There are three questions that will help to define the reader as follows;

- What does the reader know?
- What are the reader's attitudes?

- What does the reader want from the report?

It is only when the purpose of the report is defined and clearly understood that it is possible to start the process of planning the report. Understanding the reader will guide the way in which the information in the report is presented.

7.3 Structure and Materials

7.3.1 Structure

During the development of the monitoring plan the requirement for preparing and issuing reports should have been considered when considering the scheduling of activities the availability of human resources. The time for data collection, processing and reporting will have been built into the timetable to enable the issues deadlines to be met.

Time spent planning of the structure and content of the report will save time later by eliminating the need to move blocks of text between different sections of the report and reducing repetition. Structured planning with intermediate milestones, draft text stages, will ensure that the report is issued on time and of a high quality.

If the report is to be written by a team, it is important that all the members of the team are involved in the planning process. This will ensure that any constraints on the production of the report are identified at the earliest possible stage in the planning process.

The approach to planning follows the following steps

Step 1: Decide the chapter titles that will make up the report

Step 2: List in each chapter and the sub-sections to be included and all the points to be mentioned in that section. Flag information that will be needed, in particular, information from outside organizations. List all ideas - less important ones will be screened out later in the planning.

Step 3: Highlight the most important points and, when preparing a leading report, the essential points to be put forward in the reasoning.

Step 4: Delete the least important ones, points that might be irrelevant or dilute the message or reasoning.

Step 5: The points that remain, the un-highlighted ones, may be of interest to some readers. Some of these could be included in the appendices.

Step 6: Arrange the points in a final, logical sequence that will best meet the objective of the report.

Step 7: Have agreed the structure and content of the report, use this structure to generate a formatted template document that should then be issued to all of the authors who will be contributing text to the report.

Example structures for a factual report, instructional report and a leading report can be found in the Guidelines. Table 7.3-1 shows an example of table of contents of factual report. These are indicative structures to indicate how the content may be organized into a systematic order that will aid both the writer and the reader.

Table 7.3-1 Example of Table of Contents of Factual Report (Annual Water Quality Report)

1 Introduction	4 Results and discussion
2 Background	4.1 River Kennet
2.1 Historic water quality	4.1.1 Physical determinands
2.2 Trends in water quality	A. Conductivity
2.3 Sources of pollution	B. Turbidity
2.4 Impacts on beneficial uses	C. Suspended solids
2.5 Measures in place to minimize impacts	D. …………
3 Methods and Materials	E. Discussion of compliance, trend etc
3.1 Locations and characteristics of sampling locations	4.1.2 Organo-leptic
3.2 Timetable of sampling	A. Color
3.3 Field procedures	B. Odor
3.3.1 Sampling	C. Discussion of compliance, trend etc
A. Bankside	4.1.3 Inorganic determinands
3.3.2 Bridge	A. Nitrogen
B. Boat	a. Nitrate
3.3.3 In-situ measurements	b. Nitrite
A. Dissolved oxygen	c. Ammonia
B. Temperature	d. Organic nitrogen
C. pH	e. Discussion of compliance, trend etc
D. Aesthetic	*Carry on to include all of the groups described in Section 3*
3.3.4 Sample preservation	4.2 River …………………..
3.4 Laboratory procedures	5 Conclusions
3.4.1 Physical determinands	5.1 Introduction
A. Conductivity	5.2 Overall monitoring plan
B. Turbidity	5.3 Compliant determinands
C. Suspended solids	5.4 Non-compliant determinands
D. …………	
3.4.2 Organo-leptic	References
A. Color	
B. Odor	Appendix A - Details of sampling stations
3.4.3 Inorganic determinands	Appendix B - Equipment list
A. Nitrogen	Appendix C - List of laboratory methods used
a. Nitrate	Appendix D - Tables of monthly results
b. Nitrite	Appendix E - Tables of QC results
c. Ammonia	Appendix F - List of water quality standards
d. Organic nitrogen	
B. Phosphorus	
a. ortho-phosphate	
b. total phosphate	
C. Silica	
D. ………….	
3.4.4 Heavy metals	
A. Cadmium	
B. Copper	
C. Lead	
D. Mercury	
E. Nickel	
F. ……………….	
3.4.5 Organic determinands	
A. BOD	
B. Loss on ignition	
C. …………….	
3.4.6 Trace organic compounds	
A. Herbicides	
a. Atrazine	
b. Diuron	
c. Symazine	
d. …………..	
B. Pesticides	
a. Diazinon	
b. Methoxychlor	
c. ………	
3.4.7 Microbiological	
A. Faecal streptococci	
B. E coli	
C. ………..	
3.5 Quality control procedures	
3.6 Statistical analysis	
3.6.1 Excel	
3.6.2 AARDVARK	

Source: JET

7.3.2 Materials

The report would typically be made up of the following parts

(1) Title Page
This is not necessarily the cover page. However, it is the first page inside the report and normally carries the main information about the report and should include:

a) Title
b) Sub-title (if any),
c) Date,

It is important not to overcrowd the page. A clear, simple layout is always the best, Keep the external cover for graphics and photographs.

(2) Summary
A summary is essential if the report is long. It is NOT a re-statement of the conclusions. It must enable readers who do not need to know the details of the report to understand:

- Why the report has been written
- The purpose of the report
- How the information was obtained
- The key facts
- Any conclusions and/or recommendations

For a short report a summary of less than a page may be sufficient. The summary should never be more than ten percent of the main report.

(3) Table of Contents
The table of contents (ToC) of short reports may be shown on the title page. It may not even be required at all. Most reports will however require a ToC to enable the reader to find their way to sections of the report that are of particular interest to them. In such a case the ToC should always be on a separate page or pages.

A typical ToC will list the major sections or chapters, sub-sections, and appendices and give their page numbers. It should be laid out clearly so as to show the relationship between them. Consideration should be given to the lowest level of sub-section that is shown in the ToC. In some cases Level 1 may be sufficient, while in others it may be necessary to go to Level 3. The level used will be dictated by the way that levels have been used in the structure of the main body of the report. If a summary, table of abbreviations, references and bibliography are included in the report these should be listed in the ToC in the order in which they occur in the report.

(4) Introduction
The introduction provides the reason for the report, and shows why it was necessary. It states what the report aims to do report, its intended readership, and the scope of the report. It will probably list the type of facts, recommendations and conclusions that are in the report but it should not give them. That is the purpose of the results/discussion/conclusion section and to a lesser extent the summary. The shorter the introduction it is, the better.

(5) The Body of the report
This is usually the largest part of the report and contains the detailed facts and findings, shows how they were arrived at, and indicates the inferences to be drawn from them, all in accordance with the plan.

The body of the report would normally contain

1) Background
Background is explaining briefly the previous water quality in the river and whether it has been improving or deteriorating. Summarizing the main causes of pollution and how water quality is affecting the recognized beneficial river water uses.

2) Methods and Materials
Methods and Materials are explaining:

- what monitoring was carried out,
- how it was done,
- at what locations,
- how often was it done
- what quality control (QC) procedures were in place and
- what methods were used to quantify the concentrations of contaminants, and
- what methods were used to analyze the data.

Other detailed information regarding methodologies should be put into an appendix.

3) Results and Discussion
Detailed tables of numbers in Results and Discussion should not be included in the body of the report. It is more appropriate for these to be placed in an appendix and summary tables for figures to be used in the main body of the text. For ease of reading it is preferable to divide the results and discussion into subsections with the first level of division at the geographical level, i.e., by river, lake, coastal region or aquifer. Within each geographic the division would be by determinand. Further divisions would be applied as appropriate. The objective is being to enable the reader to navigate their way through the report with ease and to find their way back to a topic with the minimum of searching.
In order to avoid un-necessary repletion of figures the discussion of the compliance of each determinand with the applicable standard is best covered in the same section as the description of the determinand. There is no single right way structuring the subsections. How it is done will depend on the complexity of the monitoring that is being reported and the way in which that the key readers will want to.

(6) Conclusions
Conclusions are the opportunity to pull together the main points of the discussion and formalize the conclusions that can be drawn. These may be in relation to the monitoring methodology and the results of the monitoring. The conclusions must be based on facts that have been presented in the Results and Discussion section of the report.

(7) Recommendations
Recommendations are not always required, especially if the objective of the report is to pass on certified results of analysis that someone else will interpret and report on. Where recommendations are made they are more likely to be followed if the benefits of implementing them are clearly set out and supported by facts presented by the monitoring plan.

(8) Appendices
Appendices are used in reports that contain supporting information, or perhaps information that only some of the readers will wish to access. This information would be put into the appendices.
Typical information that would be put into appendices include:

- Large tables that are too complex to include in the main body of the report.
- Supporting secondary information
- Details of laboratory analytical procedures (unless the subject of the report)
- Timetables and itineraries.

- Figures and drawings that need to be a larger page size than the main volume to be legible.
- Photographs
- Project management tables.
- Details of attendees at meetings.
- Blank and, in some cases, completed questionnaire and survey sheets.
- Detailed financial information.

Appendices may be bound into the main report or if particularly large bound as a separate volume. Appendices should be listed in the table of contents showing their number and title. The contents of each appendix should be listed at the front of each appendix.

(9) References and/or Bibliography.
The reference list contains the details of books and articles that were consulted during the preparation of the report. The details of the source must be sufficient for the reader to be able to gain access to a copy of the document in order to verify the facts that have been used in the report. The bibliography contains details of suggested books and articles for further reading. The documents listed are there for the reader to extend their knowledge of the subject of the report further or to provide additional background information but not information that is used in the drawing of conclusions or the formulation of recommendations.

(10) Glossary or Nomenclature
Glossary or Nomenclature would not be included in day to day reporting of monitoring activities. If necessary is it used to describe particular technical terms that are used in a report that are too long to describe in the main body of the report or the description would disturb the information flow or argument.

7.3.3 Style and Presentation

Style and Presentation refers to the way in which the material is presented to the reader.
The style in which the report is written will to a large extent be driven by the type of report being written.

- A factual report may contain very little written text and consist largely of tables of data and graphical representation of the data.
- An informative report is likely to written using technical terminology using simple sentences.
- A leading report will, by its very nature, contain large passages of written text using the language to persuade the reader though strength of argument to come to a particular conclusion.

7.4 Finilization of the Report

Familiarity with a report tends to blind the reader to small mistakes. Even if the Quality Management System does not require the document to be checked before being distributed consider asking a colleague to read it through.

A checklist is a useful tool for carrying out the final sweep of the report and ensures that all parts of the document including the appendices have been compiled correctly added either electronically or physically. Before the report is submitted for approval it is important to ensure that the report:

a) Fulfills its objectives,
b) Follows a logical structure,
c) Is complete with regard to tables, figures appendices etc
d) Has no spelling or grammatical errors.

Typical elements of a checklist are provided in the Guidelines for Writing Environmental Monitoring Reports (See Appendix 4).

CHAPTER 8 ESTABLISHMENT OF DATA MANAGEMENT SYSTEM

8.1 Introduction

Water quality monitoring data management system (WQDMS) is an essential element of Quality Assurance and Quality Control (QA/QC). The objectives of WQDMS are to have clear and concise records of the procedures and to avoid recording wrong data and losing past data. Especially from the view points of data management, it is very important for managing agency to secure traceability of analyzed data which then will be converted to information provided to the public.

8.2 Setting Rules of Data Management System

As a first step to establish a data management system, rules of data management system shall be identified such as preparation of format of monitoring result to be stored, setting rules for data inputting, data checking, data sharing, and data-back-up through discussion in the monitoring section. Among the five target DONREs, the database management system in the environmental monitoring section of TT-HUE DONRE has not been established yet. Therefore the environmental monitoring section of TT-HUE DONRE decided to establish the structured water quality monitoring data management system (WQDMS) as one of the project activities.

8.3 Preparation of Manual for Data Management System

A draft manual for data management was prepared to enable staff to manage the database properly as part of their normal daily work and also shows staff their roles in the data management process. This manual provides necessary information for the database manager of monitoring section of DONRE. Though this manual is mainly written for the staff who have the responsibility for updating and maintaining the water quality database, the other staff also need to follow the principles of this document.

The manual can be prepared based on the framework of data management system which DONRE defined. The manual includes data format of monitoring result to be stored, rules for data inputting, data checking, data sharing, and data-back-up. Table 8.3-1 shows the table of contents of draft manual for WQDMS for monitoring section of TT-HUE EPA. The draft manual is shown in Annex -2.

Table 8.3-1 Example of Table of Contents for Draft Manual for WQDMS

1 Introduction
2 Database Structure
3 Data flow
4 Database Format
4.1 Regular Monitoring Program
4.2 Database Format
5 Database Management and Backup
5.1 Database Management
5.2 Database Backup
5.2.1 Save the data into the backup folder
5.2.2 Transfer the backup folder to an External Hard Disk
5.2.3 Create backup CDs
5.3 Rule of making label of CDs
5.4 Keep the backup CDs

Source: JET and TT-HUE DONRE EPA

8.4 Operation of Data Management System and Revision of Data Management System

WQDMS can be operated based on the above manual such as inputting results of monitoring into a formatted database by monitoring staff , checking inputted data by head, data sharing, and back up. WQDMS can also be revised as necessary based on identification of difficulties on its operation.

BIBLIOGRAPHY

There are many books on the topic of surface water chemistry and ecology. The following lists provides a source of basic reference material which if read will improve the understanding of the relationship between chemistry, ecology and he environment.

The Statistical Handbook and the Report Writing Handbook contain their own bibliographies, the list below relate to other topics within the Manual

1. Environmental Chemistry and Ecology.

A. Hydrology Project. Government of the Netherlands Technical Assistance to the Indian Central Water Commission.

Module 20 Introduction to Microbiology
http://cwc.gov.in/main/HP/download/20%20Introduction%20to%20Microbiology.pdf

Module 22 Coliforms as Indicators of Faecal Pollution
http://cwc.gov.in/main/HP/download/22%20Coliforms%20as%20Indicator%20of%20Faecal%20Pollution.pdf

Module 25 Oxygen Balance in Surface waters
http://cwc.gov.in/main/HP/download/25%20Oxygen%20balance%20in%20Surface%20Waters.pdf

Module 26 Basic Ecology Concepts
http://cwc.gov.in/main/HP/download/26%20Basic%20Ecology%20Concepts.pdf

Module 27 Surface Water Quality Planning Concepts
http://cwc.gov.in/main/HP/download/27%20Surface%20Water%20Quality%20Planning%20Concepts.pdf

Module 28 Major Ions in water:
http://cwc.gov.in/main/HP/download/28%20Major%20Ions%20in%20Water.pdf

Module 31 Behavior of Trace Compounds in Aquatic Environment
http://www.cwc.gov.in/main/HP/download/31%20Trace%20Compounds%20in%20the%20Aquatic%20Environment.pdf

B. UK Open University: Open Learning Source Material

Environmental Science: S278_15. Energy Resources – Water Quality.
http://www.open.edu/openlearn/science-maths-technology/science/environmental-science/energy-resources-water-quality/content-section-1.1

Environmental Science: Surface Water -Rivers.
http://www.open.edu/openlearn/science-maths-technology/science/environmental-science/surface-water/content-section-2

2. Monitoring design, field work and data use.

Bartram J. and R. Balance. Water Quality and Monitoring – A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. United Nations Environment Programme and World Health Organisation. 1996 UNEP/WHO.
http://www.who.int/water_sanitation_health/resources/wqmonitor/en/

3. Streeter-Phelps Model

A. Introduction and basic concept.
http://en.wikipedia.org/wiki/Streeter-Phelps_equation

B. Modified Streeter Phelps to include additional processes
http://mosfet.isu.edu/classes/Sato/ENVE615/S13/7-Modified%20Streeter-Phelps_S13.pdf

C. Application of Streeter Phelps model to Dong Ba and Bach Yen River, Hue City

Hoang Ngoc Tuong Van and Tran Quang Loe. Assessment of the Assimilative Capacity of Dong Ba and Bach Yn River Branches, Hue City. Journal of Science, Hue University, Vol 70, No 1 (2012) 99275-288.
www.hueuni.edu.vn/portal/data/doc/tapchi/26.pdf

PART II:

OUTLINE OF IMPLEMENTED TRAINING

CHAPTER 1 GENERAL

1.1 Introduction

The Project activities related to monitoring performance cover main five technical fields on 1) development of monitoring plan, 2) water sampling and on-site measurement, 3) water quality analysis and QA/QC, 4) data analysis and report preparation, and 5) establishment of data management system. These five technical fields are divided into two components; one is the "monitoring component" mainly for monitoring section in DONRE which covers 1) reviewing/revising monitoring plan, 4) data analysis and report preparation, and 5) establishment of data management system. The other one is the "water quality analysis component" mainly for analysis section in DONRE which covers 2) water sampling and on-site measurement and 3) water quality analysis and QA/QC.

1.2 Approaches to Capacity Development (CD) for Improving Monitoring Performance

As the first step of the Capacity Development (CD) for improving monitoring performance, JET implemented Capacity Assessment (CA) to check current capacities at the levels of individual (working level), organization and institution/society (managing level), and to set the baseline for the objectively verifiable indicators described in PDM concerning monitoring. Based on the gaps between the current capacity and the capacity necessary to fulfill the mandates given to DONRE as well as the objectively verifiable indicators, the Project prepared a capacity development plan. Table 1.2-1 and Table 1.2-2 show the conditions of capacities of each DONRE at the beginning of the Project (May 2011) and the capacities to be improved in monitoring and water quality analysis.

JET also prepared Work Plans (WP) for monitoring and water quality analysis in August 2011 1) to clarify actual capacity development activities and scheduling, 2) to identify indicators and targets of the activities for evaluation, 3) to conduct activities in accordance with WP, and 4) to reflect results and lessons to WP for the next working period.

Table 1.2-1 CD Approach for Monitoring of each DONRE

Item	HNI	HPG	TT-HUE	HCMC	BRVT
(1) Key points to be improved	a) improvement of skill for reviewing monitoring plan b) improvement of skill for data analysis and report preparation to identify characteristic of water pollution	a) improvement of skill for understanding the monitoring plan prepared by PPC and reviewing it b) improvement of data analysis and report preparation skill to identify characteristic of water pollution	a) improvement of skill for understanding the monitoring plan prepared by PPC and reviewing it b) improvement of data analysis and report preparation to identify characteristic of water pollution c) lack of data management system	a) skills for understanding the monitoring plan prepared by PPC and reviewing it b) improvement of data analysis and report preparation to identify characteristic of water pollution	a) skills for understanding monitoring plan prepared by SEMLA and reviewing it b) improvement of data analysis and report preparation to identify characteristic of water pollution
(2) Approach of CD activity	a) reviewing monitoring plan - lecture and workshop b) data analysis and report preparation - lecture and OJT	a) reviewing monitoring plan - lecture and workshop b) data analysis and report preparation - lecture and OJT	a) reviewing monitoring plan - lecture and workshop b) data analysis and report preparation c) data management - group exercise and OJT	a) reviewing monitoring plan - lecture and workshop b) data analysis and report preparation - lecture and OJT	a) reviewing monitoring plan - lecture and workshop b) data analysis and report preparation - lecture and OJT
(3) Figures/ status of before the Project	a) surface water quality monitoring stations are necessary to reviewed b) DONRE does not analyze monitoring data to identify characteristic of water pollution	a) monitoring section has never been fully involved to develop monitoring plan because the monitoring plan was prepared by an independent consultant for PPC b) DONRE does not analyze monitoring data to identify	a) monitoring section has never been fully involved to develop monitoring plan because the monitoring plan was prepared by an independent consultant for PPC b) DONRE does not analyze monitoring data to identify	a) monitoring section has never been fully involved to develop monitoring plan because the monitoring plan was prepared by an independent consultant for PPC b) DONRE does not analyze monitoring data to identify	a) monitoring section has never been fully involved to develop monitoring plan because the monitoring plan was prepared by an independent consultant under SEMLA Project b) DONRE does not analyze monitoring

Item	HNI	HPG	TT-HUE	HCMC	BRVT
		characteristic of water pollution	characteristic of water pollution c) DONRE doesn't have data management system for monitoring results	characteristic of water pollution	data to identify characteristic of water pollution
(4) Figures/ status of after the Project	a) improve monitoring plan with clear objective b) optimize locations, frequency, and determinands based on its objective c) revise annual monitoring report to describe not only compliance with QCVN and last 2 years historical trend but also characteristic of water pollution	a) same as HNI DONRE	a) same as HNI DONRE b) establish data management system	a) same as HNI DONRE	a) same as HNI DONRE
(5) Expected outcomes	a) improved monitoring plan b) revised annual monitoring report	a) improved monitoring plan b) revised annual monitoring report	a) improved monitoring plan b) revised annual monitoring report c) manual for data management system	a) improved monitoring plan b) revised annual monitoring report	a) improved monitoring plan b) revised annual monitoring report
	common outcomes: handbook for improvement of water quality monitoring activities at the target DONREs which is summarized based on the project activities				
(6) Goal	a) CENMA can review monitoring plan with clear objective b) CENMA can prepare revised annual report with characteristic of water pollution based on data analysis	a) CEM can develop monitoring plan with clear objective by themselves b) CEM can prepare revised annual report with characteristic of water pollution based on data analysis	a) EPA can develop monitoring plan with clear objective by themselves b) EPA can prepare revised annual report with characteristic of water pollution based on data analysis c) EPA can operate data management system for monitoring results by themselves	a) HEPA can develop monitoring plan with clear objective by themselves b) HEPA can prepare revised annual report with characteristic of water pollution based on data analysis	a) CENMA can develop monitoring plan with clear objective by themselves b) CENMA can prepare revised annual report with characteristic of water pollution based on data analysis
(7) Conceivable indicator and target	a) Revised monitoring plan in the Red River is prepared to propose PPCs. b) Revised monitoring reports in 2012 are prepared by DONREs, and it is shared with concerned organizations.	a) Revised monitoring plan in the Re River is prepared to propose PPCs. b) Revised monitoring reports in 2012 are prepared by DONREs, and it is shared with concerned organizations.	a) Revised monitoring plan in the Houng River is prepared to propose PPCs. b) Revised monitoring reports in 2012 are prepared by DONREs, and it is shared with concerned organizations.	a) Revised monitoring plan in the Sai Gon River is prepared to propose PPCs. b) Revised monitoring reports in 2012 are prepared by DONREs, and it is shared with concerned organizations.	a) Revised monitoring plan in the Dinh River is prepared to propose PPCs. b) Revised monitoring reports in 2012 are prepared by DONREs, and it is shared with concerned organizations.

Source: JET

Table 1.2-2 CD Approach for Water Quality Analysis of each DONRE

Item	HNI	HPG	TT-HUE	HCMC	BRVT
(1)key points to be improved	Improvement of POPs analysis	Improvement of basic water quality analysis	DONRE doesn't have know-how for operating the lab, sampling and analyzing basic determinands.	Lack of QA/QC controlling for the result from outsourced lab	Improvement of advanced water quality analysis, such as AAS and GC
(2) Approach of CD activity	Lecture, training, and OJT	Lecture, training, and OJT	Lecture, training, and OJT	Lecture and training	Lecture, training, and OJT
(3) Figures/ status of before the Project	Lab hasn't established the method to analyze POPs.	Lab conducts water quality analysis based on their SOP. But, they want to confirm their analysis method.	DONRE does not conduct water quality analysis, and the lab is under construction	Quality of the result from other lab is checked by the simple method (ex. comparing to the last data etc.)	Lab conducts water quality analysis based on their SOP. However, they face difficulty in AAS and GC analysis.
(4)Figures/ status of after the Project	Ensure reliability of monitoring results	Achieve capability of water quality	Establish the system of water sampling	Achieve capability of checking the	Achieve capability of water quality analysis

Item	HNI	HPG	TT-HUE	HCMC	BRVT
	on POPs analysis.	analysis and lab management to make trustable results	and analysis with ensuring reliability of data.	water quality analysis result of the external laboratory.	of using AAS and GC to make trustable analysis results
(5) Expected outcomes	a)Improved water quality analysis result b) SOPs for POPs analysis	a)Improved water quality analysis result b)Revised SOPs for Basic water quality analysis	a)Water quality analysis result b) SOPs for water quality analysis c)Records for laboratory management	Water quality monitoring report	a)Improved water quality analysis result b)Revised SOPs for water quality analysis
(6) Goal	Several staff measure POPs with QC	Lab staff measure basic determinand with QC	Lab staff measure basic determinand based on standard method	DONRE outsources water quality analysis with QC	Lab staff use GC and AAS with QC as regular activity
(7) Conceivable indicator and target	a) Linearity of each analytical determinand meet the provided criterion, in principle R2>0.98. b) Limit of quantization of each analytical determinand calculated from the MDL test is less than 1/10 of the limit value shown in Table 1, A1 grade in QCVN 08: 2008/BTMNT. c) Difference of duplicate analysis is less than 30%.	a) Linearity of each analytical determinand meet the provided criterion, in principle R2>0.99. b) Limit of quantization of each analytical determinand calculated from the MDL test is less than 1/10 of the limit value shown in Table 1, A1 grade in QCVN 08: 2008/BTMNT. c) Difference of duplicate analysis is less than 20%.	a) Linearity of each analytical determinand meet the provided criterion, in principle R2>0.98. b) Limit of quantization of each analytical determinand calculated from the MDL test is less than the limit value shown in Table 1, A1 grade in QCVN 08: 2008/BTMNT. c) Difference of duplicate analysis is less than 20%.	DONRE prepare the standard method for controlling the quality of data from outsourced lab.	a) Linearity of each analytical determinand meet the provided criterion, in principle R2>0.99 (R2>0.98 in GC). b) Limit of quantization of each analytical determinand calculated from the MDL test is less than 1/10 of the limit value shown in Table 1, A1 grade in QCVN 08: 2008/BTMNT. c) Difference of duplicate analysis is less than 20% in AAS, and =<30% in GC.

Source: JET

CHAPTER 2 OUTLINES OF THE TRAINING ACTIVITIES

2.1 Training Activities of Monitoring Component

Based on the approaches to capacity development described in Chapter 1, JET and DONRE set framework for implementation of CD activities of monitoring component. There are eight technical aspects for capacity development on monitoring in accordance with the five activities under scope of the Project as shown in Table 2.1-1.

Table 2.1-1 Framework for Implementation of CD activities on Monitoring

Activities	Technical Aspects	Approach	Actual activity	Target
1. Review water quality monitoring guidelines/manuals.	1) Preparation of guidelines/ manuals	There are many documents related to monitoring that were developed not only in Vietnam but also in foreign countries. JET reviewed the above documents and prepared "Handbook for Improving Monitoring Performance" based on the documents and implemented project activities.	1. Discussion meeting and seminar were implemented as follows; a) Discussion meeting for introduction of existing monitoring guidelines/ manuals b) Seminar and discussion meeting to share the Handbook for Improving Monitoring Performance and change its opinions	1.Target Organization HNI, HPG, TT-HUE, HCMC, BRVT DONRE 2.Target staff Staff who are in charges of monitoring and water quality analysis 3.Target stakeholders Water resource management division, pollution control division in DONRE
2. Based on above guidelines/manuals (revised if necessary), laws and regulations in Vietnam, and international guidance, prepare/improve a monitoring plan, taking into consideration of regional characters at target DONREs.	2) Preparation/ revision of water quality monitoring plan	Most of monitoring plans were developed by not DONRE themselves but by local consultants for PPCs, thus they needed to clarify objectives of monitoring as the first step to get basic skill and knowledge for development of monitoring plan. In this connection, JET provided the following training; 1. Utilization of the Data Quality Objective (DQO) process for revising water quality monitoring plan regarding the following items. a)Formalizing monitoring procedures b)Numbers and locations of sampling stations c)Frequency of sampling d)Determinand of measured	1. Lectured training and workshop were implemented as follows; a) Introduction training for DQO Process (1 day training at each DONRE) b)Workshop for designing water quality monitoring plan based on DQO Process (3 days workshop at each DONRE) c)OJT for development of revised monitoring plans of key rivers	1.Target Organization HNI, HPG, TT-HUE, HCMC, BRVT DONRE 2.Target staff Staff who are in charges of monitoring 3.Target stakeholders Analysis division of Monitoring Center, water resource management division, pollution control division in DONRE
3. Implement regular monitoring in accordance with laws and regulations in Vietnam.	3) Implementation of regular monitoring	All DONRE has already implemented regular monitoring in accordance with their existing monitoring plans. Thus JET followed up on implementation of regular monitoring by DONRE as necessary.	1. Discussion meetings were implemented combined with other activities.	1.Target Organization HNI, HPG, TT-HUE, HCMC, BRVT DONRE 2.Target staff Staff who are in charges of monitoring 3.Target stakeholders Analysis division of Monitoring Center
4. Conduct training on water quality monitoring including quality control for improving reliability of monitoring. (note: change training contents based on situations of target DONREs)	4) QA/QC in sampling and laboratory analysis	Establishment of QA/QC procedures were applied to in-house laboratory analysis or to outsourced laboratory work (See detail in Work Plan of WG 2-2: Water Quality Analysis)	See detail in Work Plan of WG 2-2	See detail in Work Plan of WG 2-2
	5) QC for monitoring data by statistical techniques	Most of DONRE did not check monitoring results from the view point of statistics, thus they needed to get techniques such as reliability of monitoring results of existing monitoring, number of sampling to get accurate results, to interpret unexpected results. In this connection, JET provides the following training; 1. Introduction of basic statistical techniques for the quantitative assessment of differences and changes in water quality based on the existing monitoring results	1. Lecture training and discussion meeting were implemented as follows; a) Lecture training for introduction of statistic techniques (1 day training at each DONRE) b) Discussion meeting to share handbook for statistical analysis of water quality data	1.Target Organization HNI, HPG, TT-HUE, HCMC, BRVT DONRE 2.Target staff Staff who are in charges of monitoring 3.Target stakeholders Analysis division of Monitoring Center
	6) Structured data management systems	Only TT-HUE DONRE did not have structured data management system including preparation of format of monitoring result to be stored, setting rules	1. Group exercise and OJT courses were implemented as follows; a) group exercise for	1.Target Organization TT-HUE DONRE 2.Target staff Monitoring division of

Activities	Technical Aspects	Approach	Actual activity	Target
		for data inputting, data checking, data sharing, and data-back-up. Therefore JET provided the following training to TT-HUE DONRE; 1. Development of structured data management systems to facilitate access to water quality data for subsequent reporting and analysis through group exercise and its operation	development of data management system (1 day) b) OJT and trial operation of data management system (continuous training)	EPA, TT-HUE 3.Target stakeholders Laboratory analysis section of EPA
5. Interpret and evaluate results of monitoring and feedback to the annual/biannual monitoring reports	7) Analysis of water quality monitoring results	Most of monitoring reports in the target DONREs described only compliance with QCVN, historical trend for last 2 years, and longitudinal trend, thus they needed to implement not only the above analysis but also to understand interaction between water environment, pollution sources, impact to water sources, pollution mechanism, and so on. In this connection, JET provided the following training; 1.Introduction of data analysis based on the existing monitoring data a)interaction between water environment and pollution sources b)relationships among contaminants c)water pollution mechanism	1. Lectured training and OJT courses were implemented. a) Basic data analysis training for checking standard, longitudinal trend, historical trend, water quality status mapping and so on (1 day training at each DONRE) b) OJT for data interpretation and application of basic statistical techniques for data evaluation	1.Target Organization HNI, HPG, TT-HUE, HCMC, BRVT DONRE 2.Target staff Staff who are in charges of preparing monitoring report 3.Target stakeholders Other divisions in Monitoring Center, water resource management division, pollution control division in DONRE
	8) Report preparation and dissemination	Besides of improvement of analysis water quality monitoring results mentioned above, JET provided the following training as report preparation and dissemination; 1. Introduction of guidelines for writing environmental monitoring report to restructure of contents and make it clear objective for readers. 2. OJT for writing environmental monitoring report based on the above guidelines.	1. Lectured training and OJT courses were implemented. a) Lecture training for introduction the guidelines (1 day training at each DONRE) b) OJT for report preparation based on the guidelines (1 or 2 days training at each DONRE)	1.Target Organization HNI, HPG, TT-HUE, HCMC, BRVT DONRE 2.Target staff Staff who are in charges of preparing monitoring report 3.Target stakeholders Other divisions in Monitoring Center, water resource management division, pollution control division in DONRE

2.2 Training Activities of Water Quality Analysis Component

Based on the approaches to capacity development, JET and the DONREs set training activities for water quality analysis. The contents of training activities are completely different among the DONREs because the capacities on water quality analysis and installed equipment of each DONRE are different. Table 2.2-1 shows training activities for water quality analysis between April 2011 and March 2013.

Table 2.2-1 Training Activities for Water Quality Analysis

DONRE	Target Point/ Field of CD	Implementation Schedule	Outcomes	Dissemination
HNI	1. Training for POPs analysis 1) Training of POPs analysis method 2) Training to identify unknown peak	2011 -May: Review and planning of POPs analysis. -Sep-Dec: OJT for POPs analysis (Pesticides) by GC-ECD. Capacity of QC is increased to achieve the target shown in Table2.2.2-3. 2012: -Feb-May: Continue OJT for POPs analysis (Pesticides) by GC-ECD -May-Dec: Lecture training and OJT for POPs analysis (PBDEs) by GC-MS -Nov-Dec:OJT to identify unknown peaks and to analyze the real samples of water	1)Improved water quality analysis result 2)SOPs for POPs analysis	SOPs and training contents will be used in lab
HPG	1. Improving Basic Water Quality Analysis and QA/QC activity 1) Sampling and on-site	2011: -May: Review current status and planning of training program -Nov: Lecture training and OJT for sampling and on-site measurement, -Oct-Dec: OJT for basic water quality analysis (BOD, PO4,NO2). 2012: -June-July: OJT for basic water quality analysis (COD, T-N, NH4,	1)Water quality analysis result in CEM	Training contents will be used in the lab

	measurement 2)Basic water quality analysis	NO3, Phenol).		
TT-HUE	1. Improving Water Quality Analysis and QA/QC activity 1)Operation of the laboratory 2)Sampling and on-site measurement 3)Basic water quality analysis	2011: -May-Jul: Capacity assessment, comment for new laboratory design, and requesting self-studying of the TCVN and Circular, Procuring equipment for on-site measurement (pH, EC, DO meter). -Sep: OJT for sampling and on-site measurement, -May-Aug: Lecture and OJT for laboratory management 2012 -Feb: Procuring equipment for lab, and installing the equipment -Feb: Initial training for registration and storage of glassware and chemical -Feb-Dec: OJT for Basic water quality analysis based on TCVN (pH, EC, Salinity, DO, COD, BOD, TSS, TDS, NO3, NO2, NH4, SO4, and PO4) Capacity of QC is increased to achieve the target shown in Table2.2.2-3. 2013 -Jan: OJT for Basic water quality analysis on COD, BOD, TDS, and NH4	Water quality analysis result in the lab Records for laboratory management	Training contents will be used in the lab
HCM	1. Improving QC activity in the water quality monitoring	2011: -May: Review current status and planning of training program 2012: -Jun-Aug: Lecture training for checking the water quality analysis result of external laboratory	Water quality monitoring report of HEPA	Training contents will be used in the department
BRVT	1. Improving Water Quality Analysis and QA/QC activity 1) Water quality analysis by GC and AAS 2) Basic water quality analysis	2011: -May: Review current status and planning of training program -Sep: Check the status of AAS and GC. Then rearrange the training plan for BRVT lab. 2012 -Feb-Dec: OJT for GC and AAS, if possible Capacity of QC is increased to achieve the target shown in Table2.2.2-3. -Jun-Aug: OJT of Fluoride and Phenol analysis. 2013 -Jun-Feb: Support for inspection of additional equipment procured by JICA. -Feb: OJT for GC and AAS.	Water quality analysis result	Training contents will be used in the lab

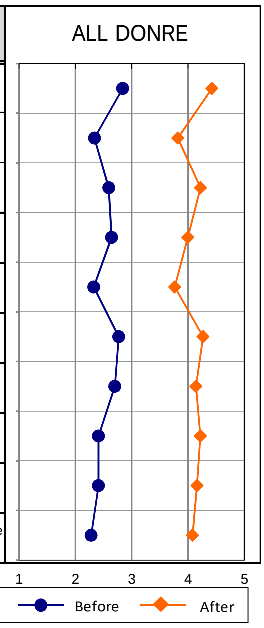
Source: JET

CHAPTER 3 IMPROVED PERFORMANCE THROUGH THE PROJECT

3.1 Results of Internal Evaluation

To grasp improvement of performance on monitoring and analysis, an internal evaluation were conducted in January 2013, Figure 3.1-1 shows the questions related to three objectively verifiable indicators (Monitoring plan, Data interpretation and monitoring report, and Accuracy of Monitoring) in the Project and the overall results of the five-level, semi-quantitative self-evaluation marked by all DONREs. The scores represent the average scores of all respondents. Before starting the Project, all of the capacities were evaluated as between "little" and "satisfactory". As of January 2013 (two years after starting the Project), all of these capacities were evaluated as around "good". Especially all questions regarding indicator 2-1-3 were evaluated more than "good".

Output of PDM (quoted from modified 11 July, 2012)	Objectively Verifiable Indicator (quoted from modified 11 July, 2012)	OP 2-1 Monitoring	Questions
Enforcement capacity of target DONREs on environmental monitoring is strengthened.	2-1-1: Draft revised monitoring plans of key rivers are prepared.	CA 2-1-1 (1)	On a scale of 1 to 5, please rate the clarity of the objectives of the monitoring plan of the key river before and after revision.
		CA 2-1-1 (2)	Can you explain and train other staff how to prepare a monitoring plan? Please rate your capacity before and after the Project.
		CA 2-1-1 (3)	Do you think the activities of revising the monitoring plan have contributed to improving DONRE's capacity to implement effective and efficient monitoring? Please rate the change in DONREs capacity before and after the activities?
	2-1-2: Draft revised monitoring reports in 2012 are prepared by DONREs, and shared with concerned organizations.	CA 2-1-2 (1)	Do you think the contents of the monitoring report include enough information for environmental officers of other departments/sections to understand overall situation of water quality in the province? Please rate the contents of the report before and after the Project.
		CA 2-1-2 (2)	Please rate your capacity, before and after the Project, to develop a monitoring report that includes enough levels of monitoring data analysis, such as analysis of historical trend and comparison of upstream and downstream data.
		CA 2-1-2 (3)	Do you think the activities of revising the monitoring report have contributed to improving effectiveness and efficiency of DONRE's monitoring? Please rate change in DONRE's capacity before and after the Project.
	2-1-3: Accuracy of monitoring is improved.	CA 2-1-3 (1)	Can you explain the concrete method of QC to other staff?
		CA 2-1-3 (2)	Do you think the technique of water quality analysis in your laboratory have improved through the Project?
		CA 2-1-3 (3)	Do you think that accuracy of water quality monitoring in your DONRE has improved through the Project?
		CA 2-1-3 (4)	Please rate the improvement in DONRE's capacity to analyze water quality before and after the procurement of the equipment by the Project.



Note: 5: Very Good, 4: Good, 3: Satisfactory, 2: Little, 1: Nothing
Source: Target DONREs compiled by JET

Figure 3.1-1 Overall Results of Questionnaire for Monitoring Performance (Average of all DONREs)

3.2 Achievement of Monitoring Component

(1) Indicator 2-1-1: Monitoring Plan

Before the Project, most of the monitoring plans had been developed, not by the DONRE themselves, but by local consultants for PPCs, thus DONRE did not know clearly the objectives of the monitoring they were carrying out.

In response to this, JET provided a series of lecture training and workshops in the first year (March 2011 – March 2012) to clarify objectives of monitoring and to obtain basic skill and knowledge for development of monitoring plan. In the second year (April 2012 to April 2013), all DONREs set the direction to revise monitoring plan of key river based on collected data and information as well as through discussion meetings with JET. Accordingly by January 2013 all DONREs have completed preparation of the draft revised monitoring plans of key rivers with support of JET. Among the target DONREs, HNI, HPG, and TT-HUE DONRE officially started new monitoring from 2013 based on the revised monitoring plans of key rivers.

As the results of CA 2-1-1 (1) and (2) in the answered questionnaires indicated in Figure 3.1-1, DONRE staff has acquired technical skills and know-how on development of monitoring plan such as identification of objective of monitoring clearly, and is now able to train other staff how to develop monitoring plan. Thus DONRE staff has improved their capacities on individual level. Besides, as the results of CA 2-1-2 (3) in the answered questionnaires suggested, DONRE staff recognized that the activities of revising monitoring plan had contributed to improving DONRE's capacity to implement effective and efficient monitoring. This implies that DONREs have improved their capacities on organization level regarding development of monitoring plan. Some DONREs have already started revising monitoring plans of other rivers in their City/Province (e.g. To Lich River monitoring plan in Hanoi City).

(2) Indicator 2-1-2: Data Interpretation and Monitoring Report

At the beginning of the Project, most of the monitoring reports in the target DONREs described only compliance with QCVN, historical trend for the most recent two years, and longitudinal trend. They needed, in addition to the above analysis, analyses of interaction between water environment, situation of pollution sources, pollution mechanism, impact of pollution to water sources, and so on.

In response to this, in the first year JET provided the lecture training on data analysis such as analysis of historical trend and comparison of upstream and downstream data in the first year. In the second year, JET provided the lecture training on statistic data analysis for water monitoring data and writing environmental monitoring report to restructure of contents and make it clear objective for readers. Based on these training programs, by February 2013, target DONREs prepared their own monitoring report in 2012 with some improvements.

As the results of CA 2-1-2 (1) and (2) indicated in Figure 3.1-1, DONRE staff have acquired technical skills and know-how on data interpretation and preparation of monitoring report, such as analysis of historical trend and comparison of upstream and downstream data, and identification of contents of monitoring report clearly. Thus DONRE staff has improved their capacities at the individual level to some extent. Besides, as the results of CA 2-1-3 (3) indicated, DONRE staff recognized that the activities of improving monitoring report has contributed to improving DONRE's capacity to implement effective and efficient monitoring. This implies that DONREs have improved their capacities on organization level regarding preparation of monitoring report.

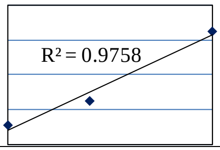
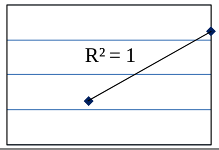
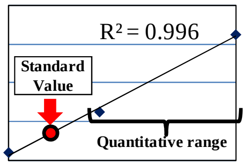
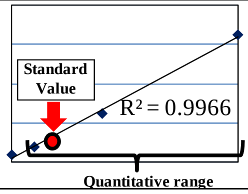
3.3 Achievement of Water Quality Analysis Component

(1) Indicator 2-1-3: Improvement of Accuracy of Monitoring

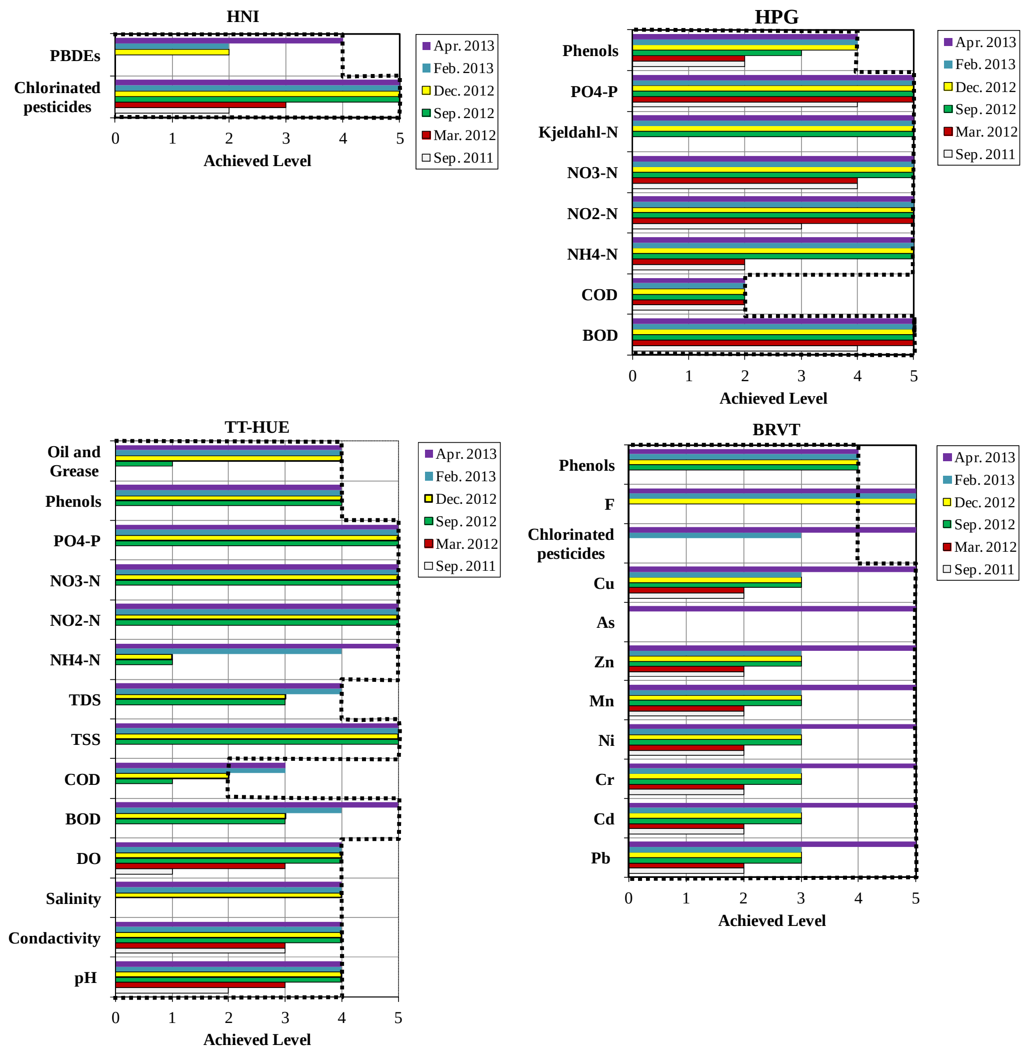
To evaluate the achievement of the indicator, the Project prepared a set of criteria specially designed for each DONRE considering the technical capacity of each monitoring center. Then, the criteria were monitored periodically by JET and progresses discussed with C/Ps. The criteria are shown in Table 3.3-1. Basically, each DONRE is expected to achieve Level 5 competency for each determinand selected, by demonstrating that the staff of the laboratory is capable of quantifying concentration at or lower than the environmental water standard value mentioned in ‘National Technical Regulation on Surface Water: QCVN08: 2008/BTNMT’, using its methodology and equipment and with enough statistical confidence. For some determinands, however, it is difficult to achieve Level 5 due to technical reasons, and for these determinands, the goals are set at Level 2 to 4, as mentioned in the remarks in Figure 3.3-1.

The levels of achievements in the relevant DONREs are evaluated as “mostly achieved”. The progress of BRVT DONRE was slower than other DONREs in November 2012, because equipment for training (GC-ECD and Furnace-AAS) had not been procured until January 2013 due to delay in release of A4 form. However, by the effort of the C/Ps and JET, BRVT DONRE caught up to other DONREs through the additional trainings in 2013.

Table 3.3-1 Level of water quality analysis in the Project

Level	Explanation	Example
-	Not available without equipment or installation	
0	Not measured ever,	
1	Measurement is conducted but without sufficient reliability. Calibration curve is drawn with 2 or less calibration points and/or R2 < 0.99.	(Example of "1")  
2	Calibration curves can be drawn (with 3 or more calibration points, R2>= 0.99) but not available for the A1 grade of Standard for Surface Water (SSW). This condition is not accurate enough.	 (Example of "2"; a quantitative range is between the lowest and highest calibration except zero)
3	Calibration curves can be drawn (with 3 or more calibration points, R2 >= 0.99) and SSW concentration can be measured accurately,	 (Example of "3"; quantitative range includes SSW concentration. So that, it can be measured)
4	Difference of duplicate analysis using natural water sample is less than 20%.	-
5	MDL (Method Detection Limit) is less than A1 grade of SSW	

Source: JET



Source: JET: The dotted line shows the expected goal of each determinand

Remark: Reasons for setting target level lower than Level 5

PBDE (Poly-Brominated Diphenyl-Ethers)	PBDEs, a group of compounds that belong to POPs, are chemical flame retardants used in plastics, upholstery fabrics, and foams in products such as computers, televisions, furniture, and carpet pads. PBDEs are showing up in the environment, in foods, in household dust, and in workplaces. PBDEs are being found at increasing levels in human blood, fat and breast milk, in the world. However, there is no environmental standard of PBDEs in Vietnam. Therefore, MDL cannot compare with the standard value. So, Level 4 is set as the goal in the Project.
Phenols	Value of "A" grade of surface water standard of phenols is 0.005mg/L. The value is lower than detection limit of the analysis method applied in Vietnam. In case of applying the method, it is impossible to get MDL less than the value. So, Level 4 is set as the goal in the Project.
COD	Value of "A" grade of surface water standard of COD is 10mg/L. The value is almost the same as the detection limit of the analysis method applied in Vietnam. It is impossible to get accurate calibration curve applying the 10mg/L as lowest standard. So, Level 2 is set as the goal in the Project.
Oil and grease	Value of "A" grade of surface water standard of oil and grease is 0.01mg/L. In case of using GC-FID, it is possible to measure the value. However, the Project doesn't procure GC for TT-HUE DONRE. JET will conduct the training for oil and grease by applying other method, Hexane Extractable Gravimetric Method, of which detection limit is higher than the standard value. Therefore, Level 4 is set as the goal in the Project.
TDS, Salinity, Conductivity	There is no surface water quality standard for these determinands. Therefore, MDL cannot compare with the standard value. So, Level 4 is set as the goal in the Project.
DO, pH	Standard value of DO and pH is not the maximum value allowed in the environment. Therefore, it is meaningless to measure detection limit of both determinands. Therefore, Level 4 is set as the goal in the Project.
Fluoride	Value of "A" grade of surface water standard of fluoride is 1mg/L. It is necessary to use steamed distillation apparatus to measure accurately. However, JET didn't procure the apparatus because fluoride analysis training was added after equipment to be procured was decided. Therefore, Level 4 is set as the goal in the Project.
Chlorinated pesticides in BRVT CEMAB	Detector of GC which is necessary for the pesticide analysis has not been delivered to BRVT yet. Considering the training schedule, it is impossible to achieve Level 5 until the end of the Project. So, the level expected to achieve was decreased to Level 4.

Figure 3.3-1 Level of water quality analysis in each DONRE

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
SOCIALIST REPUBLIC OF VIETNAM
MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MONRE)

The Project
for
Strengthening Capacity of Water Environmental Management
in Vietnam

HANDBOOK FOR
IMPROVING MONITORING PERFORMANCE

APPENDICES

JICA EXPERT TEAM

SOCIALIST REPUBLIC OF VIETNAM

The Project for Strengthening Capacity of Water Environmental Management in Vietnam

Handbook for Improving Monitoring Performance

APPENDICES

The Project for Strengthening Capacity of

Water Environmental Management in Vietnam

HANDBOOK FOR

IMPROVING MONITORING PERFORMANCE

APPENDIX I

MONITORING PLANS (DRAFT)

MAJOR RIVERS OF TARGET PROVINCES

OF THE PROJECT

Water quality monitoring plans:

- Red river, Hanoi city (Appendix I-1)
- Re river, Hai Phong city (Appendix I-2)
- Huong river, Thua Thien – Hue province (Appendix I-3)
- Saigon river, Ho Chi Minh city (Appendix I-4)
- Dinh river, Ba Ria – Vung Tau province (Appendix I-5)

MONITORING PLAN FOR WATER QUALITY IN THE RED RIVER

(Red river section flowing through HaNoi city)

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1 Objectives of the plan

The monitoring plan for Red river water quality is aimed to:

- Assess the Red river water quality to see if the water is relevant for present and future use purposes or not (if any).
- Assess historical and longitudinal trend of river water quality (comparison between years)
- Discover and supervise impacts of pollution sources on river water quality

2 Monitoring type

Impact environmental monitoring type is employed in the monitoring plan for water quality in the Red river .

3 Relevant information for the preparation of monitoring plan

3.1 Required information

Information necessary for building a system of monitoring points and determining monitoring parameters and frequency includes: river system, land use status along the river, location of water intake stations, pumping stations for water and wastewater, pollution sources along the river, regional climatic conditions, hydrological regime of the river. Such important information is displayed below. Locations of monitoring points, parameters and frequency will be presented later.

3.2 Red river system of a section running through Ha Noi and land use status

Red river system

The Red river section running through Hanoi city is about 150 km long from Ba Vi district to Phu Xuyen district. This river section flows through Phu Tho, Vinh Phuc provinces, Ha Noi city and Hung Yen province.

The Red river in Ha Noi city starts in Phong Van commune, Ba Vi district at the confluence of Da river and Thao river (the name of the Red river section from Lao Cai to Viet Tri confluence). Flowing about 16 km further, the Red river receives water from Lo river at Viet Tri confluence. From Viet Tri to Phu Xuyen, the Red river no longer receives water from any tributaries but only share its water with its distributaries. At present, the Red river can supply water for Day river through Cam Dinh gate (Cam Dinh commune, Phuc Tho district) but only for a short time of a year. Toward the downstream area, the Red river feeds water into Nhue river through Lien Mac gate (Lien Mac commune, Tu Liem district), for Duong river in Ngoc Thuy ward, Long Bien district, and for Bac Hung Hai irrigation system through Xuan Quan gate (Xuan Quan commune, Van Giang district, Hung Yen province).

The most important feature of the Red river section flowing through Ha Noi city is that a large and long dyke system can be observed along the two river banks. Therefore, the Red river in Ha Noi can only receive water from big tributaries such as Lo river, Da river, water from river bank flat and through drainage pumping stations. Meanwhile, water source of the Red river is allocated to Day river, Duong river, Nhue river, Bac Hung Hai river and provided for agricultural irrigation system through irrigation pumping stations.

The Red river system in Ha Noi city is shown in Figure 1 below.

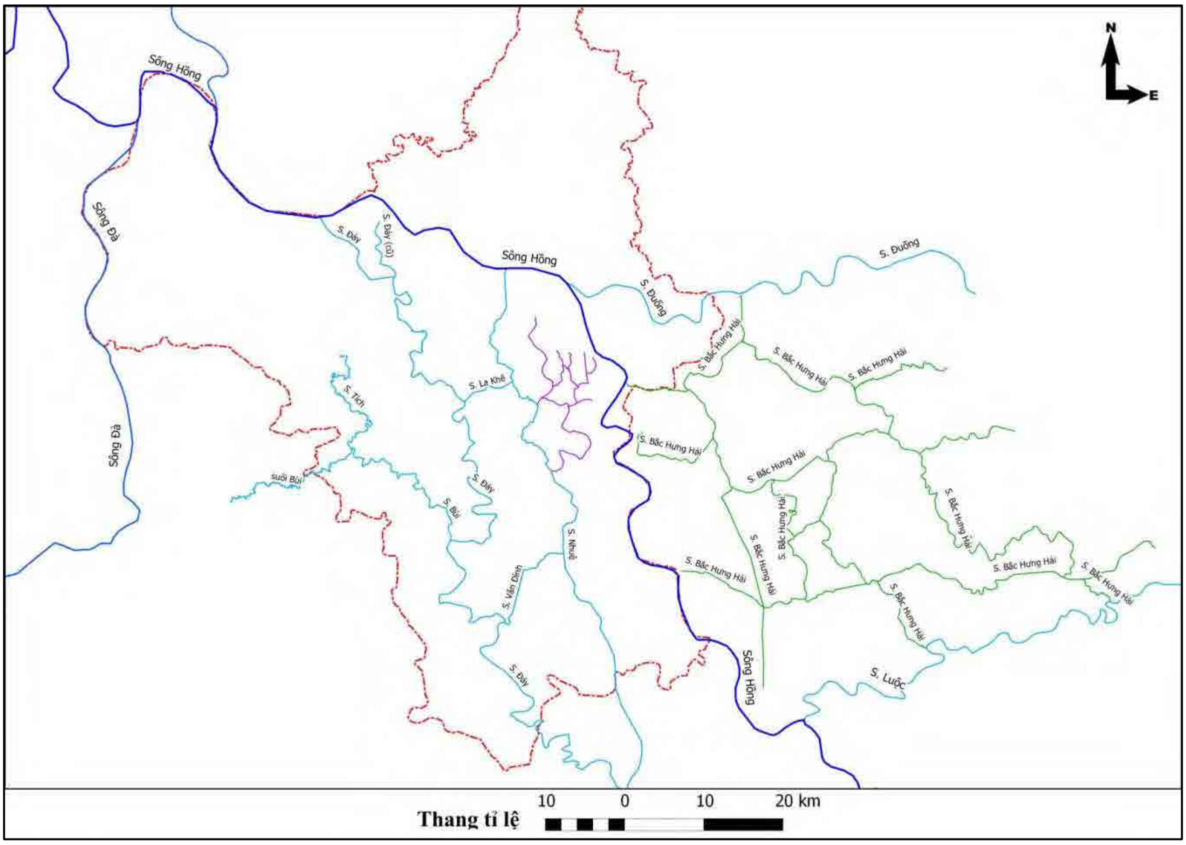


Figure 1: Red river system in Ha Noi

Figure 2 below presents Red river system in topographic base map.

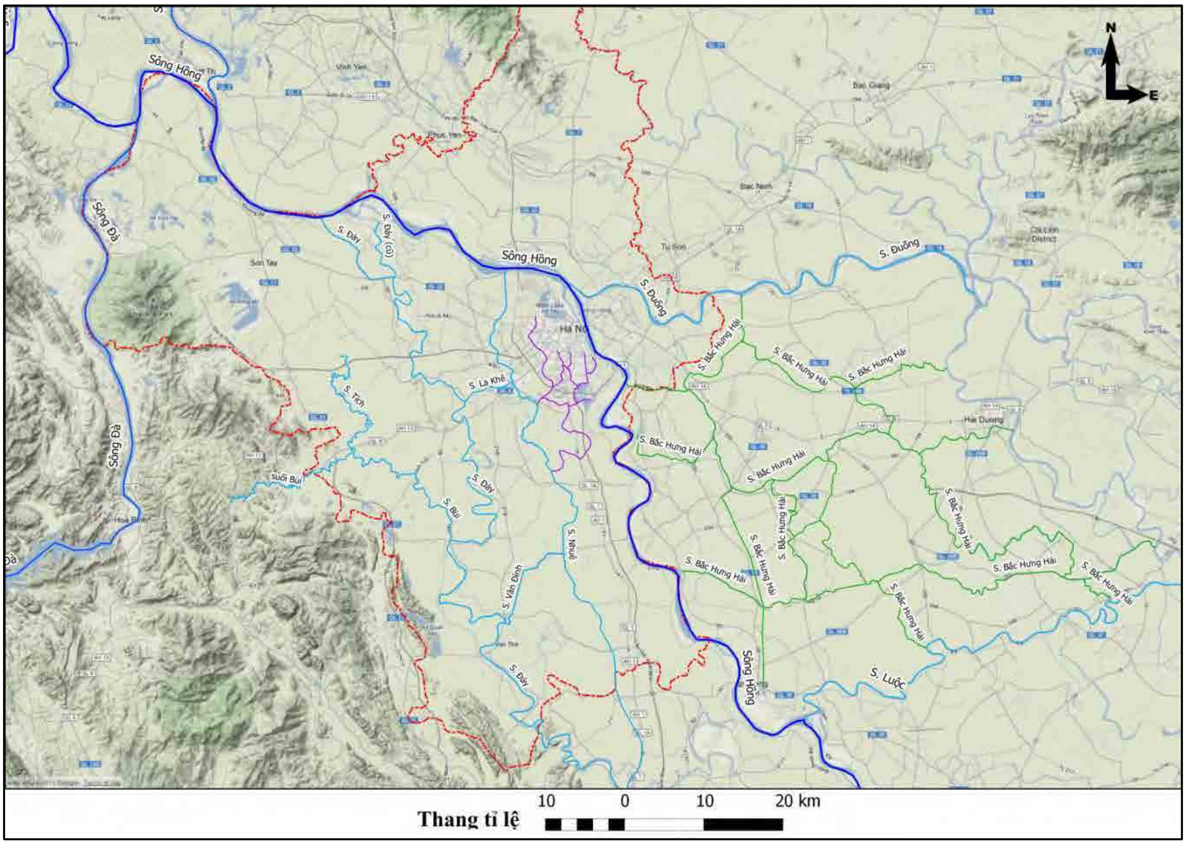


Figure 2: Red river system in Ha Noi city in the topographic base map

Land use

The Red river in Ha Noi city runs through main industrial and residential areas which are in Viet Tri city (Phu Tho province), Son Tay provincial town and inner city of Ha Noi. The remaining areas along the Red river mainly comprise paddy fields which are in a part of Ba Vi district, in districts of Phuc Tho, Dan Phuong, Me Linh, a part of Dong Anh district, Gia Lam district, Thanh Tri district, Thuong Tin district, Phu Xuyen district of Ha Noi and district Lam Thao district, Phu Tho province, districts of Vinh Tuong and Yen Lac of Vinh Phuc province, districts of Van Giang, Khoai Chau, and Kim Dong of Hung Yen province. The Red river can receive wastes from these agricultural areas through drainage pumping stations.

Figure 3 shows land use status along the Red river which flows through Ha Noi city.

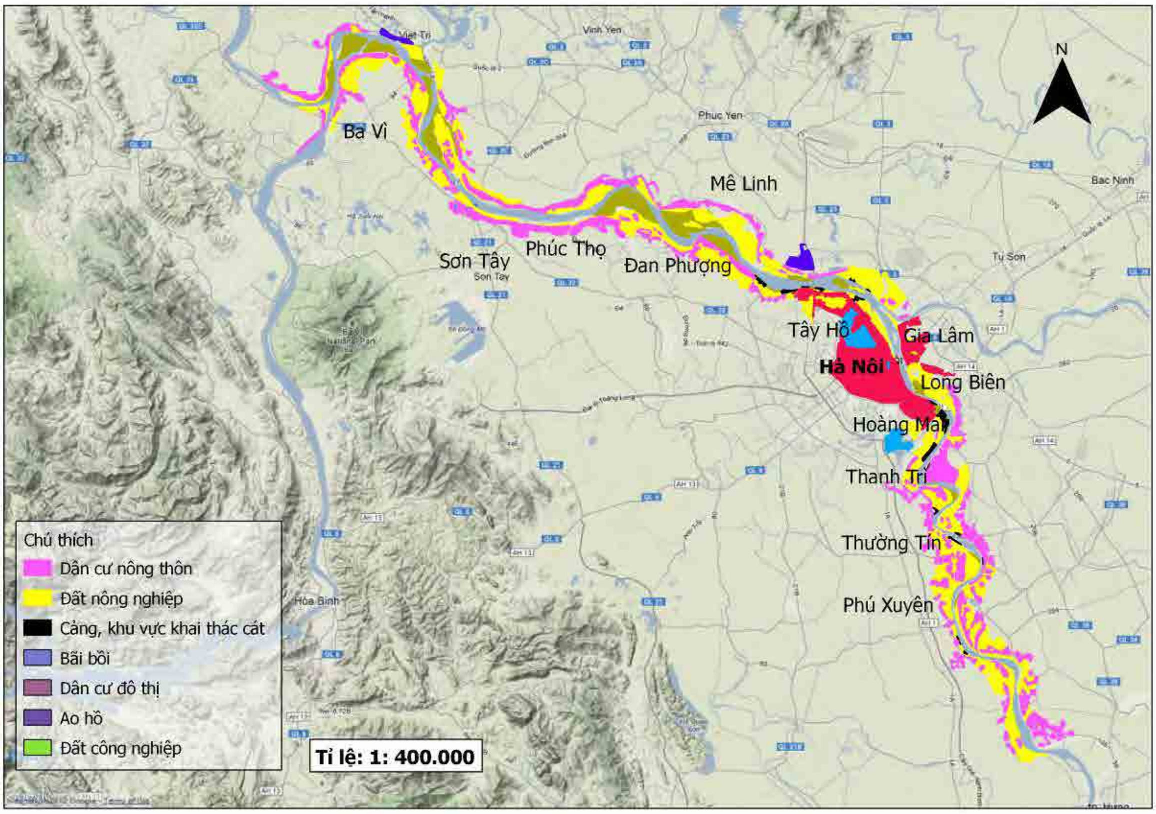


Figure 3: Map of land use zonation along the Red river section in Ha Noi city (*Source: Analysis based on satellite images*).

3.3 Location of irrigation water intake stations and pollution sources along the Red river

<u>Location of irrigation water intake stations</u>

Along the Red river section which flows through Ha Noi city and at the end of Da river and Lo river, there are about 15 water intake points including 12 pumping stations and 3 water intake gates which mainly serve agricultural water supply. In addition, according to the planning enclosed with Decision No 1590/QD-TTg (dated 09 Oct 2009) on directions for irrigation development in Viet Nam, two water intake gates Lien Nghia and Nghi Xuyen will be newly built for additional water supply from the Red river for Bac Hung Hai irrigation system. River water in these water intake stations/points needs to meet B1 column/class prescribed in QCVN 08:2008/BTNMT. Table 1 provides the list and location of pumping stations.

Table 1: List of water intake stations along the Red river section in Ha Noi

No	River	Station	Coordinates (WGS-84)		Location	Note
			Latitude	Longitude		
1	Da	Son Da pumping station	21.192849°	105.311749°	Son Da commune, Ba Vi district	
2	Da	Trung Ha pumping station	21.234734°	105.353593°	Thai Hoa commune, Ba Vi district	
3	Lo	Bach Hac pumping station	21.297762°	105.449381°	Bach Hac ward, Viet Tri city, Phu Tho province	
4	Red	Dai Dinh	21.263995°	105.447180°	Cao Dai commune, Vinh	

No	River	Station	Coordinates (WGS-84)		Location	Note
			Latitude	Longitude		
		pumping station			Tuong district, Vinh Phuc province	
5	Red	Phu Sa pumping station	21.156458°	105.509978°	Vien Son ward, Son Tay provincial town	
6	Red	Cam Dinh gate	21.150779°	105.561365°	Cam Dinh commune, Phuc Tho district	Water intake from the Red river for Day river; yet, presently, the station only operates for a short time of a year
7	Red	Xuan Phu pumping station	21.152018°	105.568534°	Xuan Phu commune, Phuc Tho district	
8	Red	Thanh Diem pumping station	21.161252°	105.648029°	Chu Phan commune, Me Linh district	
9	Red	Lieu Tri pumping station			Located on the right side of the Red river	The station location has not yet been defined (Yen Lạc district (Vinh Phuc) or Me Linh (Ha Noi))
10	Red	Dan Hoai pumping station	21.112360°	105.720897°	Between Lien Ha & Lien Trung commune, Dan Phuong district	
11	Red	Lien Mac gate	21.089494°	105.770655°	Thuy Phuong commune, Tu Liem district	The gate gets water from the Red river for Nhue river
12	Red	Ap Bac pumping station	21.103558°	105.780123°	Vong La commune, Dong Anh district	Near Thang Long Industrial Park
13	Red	Xuan Quan gate	20.971831°	105.919784°	Xuan Quan commune, Van Giang district, Hung Yen province	The gate receives water from the Red river for Bac Hung Hai irrigation system
14	Red	Hong Van pumping station	20.890170°	105.894508°	Hong Van commune, Thuong Tin district	
15	Red	Thuy Phu pumping station	20.781409°	105.934960°	Thuy Phu commune, Phu Xuyen district	There are two pumping stations of Thuy Phu: I & II
Water intake gates will be newly built according to the planning in Decision 1590/QĐ-TTg						
1	Red	Lien Nghia gate			Lien Nghia commune, Van Giang district, Hung Yen province	Water intake gate from the Red river for Bac Hung Hai irrigation system
2	Red	Nghi Xuyen gate			Nghi Xuyen hamlet, Chi Tan commune, Khoai Chau district, Hung Yen province	

Specific location of water intake gates and pumping stations is shown in the figure below.

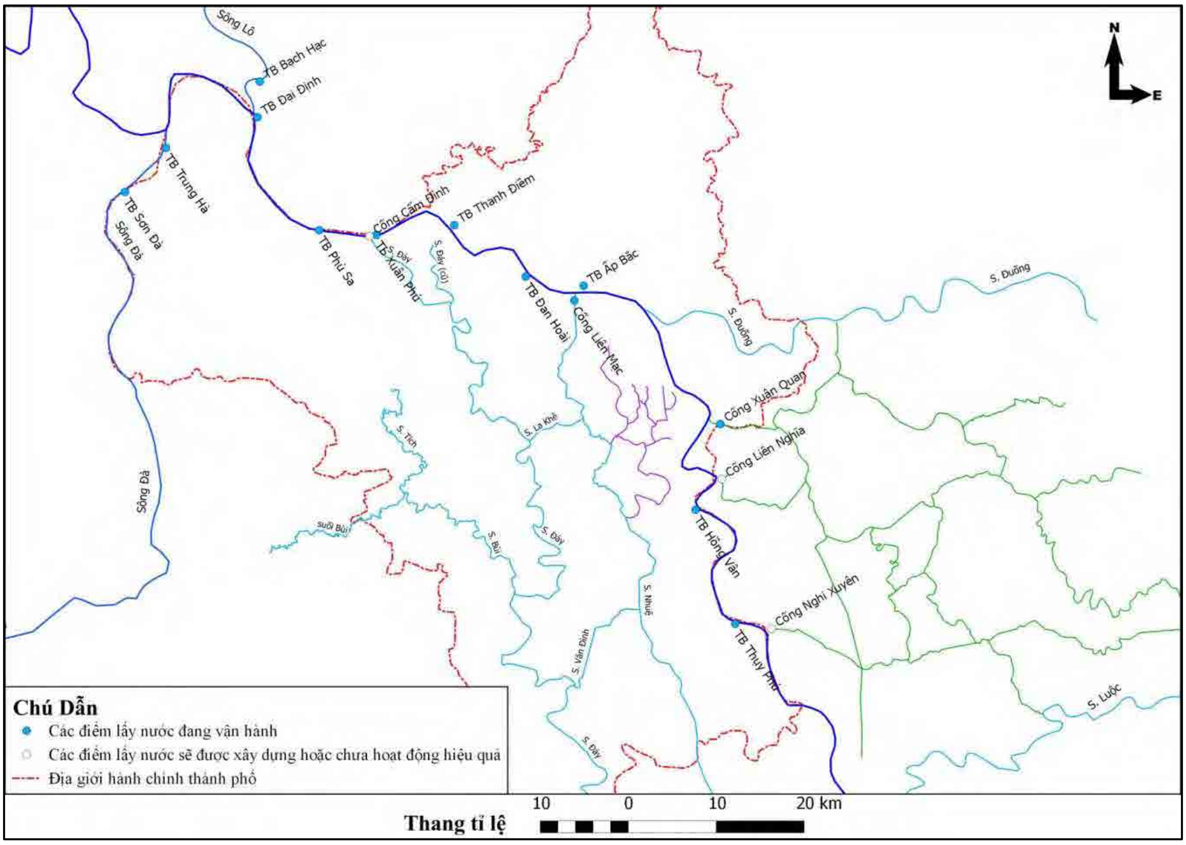


Figure 4: Location of irrigation stations along the Red river in Ha Noi city

<u>Stations for pumping water and wastewater into the Red river</u>

These pumping stations are listed in table 2 below. If the water is polluted before being pumped by the station into the Red river, the water may adversely affect the Red river water quality and considered to be a pollution source. Therefore, water quality of the Red river at the location of receiving water from pumping stations needs to be supervised. Of the 5 existing pumping stations and 7 pumping stations to be built in the future as listed in table 2, stations of water pumping from residential and industrial areas have to be taken into consideration. Attention should be paid to such pumping stations as Yen So, Dong My (receiving water from inner-area rivers of To Lich, Lu, Set, Kim Nguu), Lien Mac, Co Dien, Nam Thang Long, and Tu Dinh.

Table 2: List of stations for sewage pumping stations into the Red river

No	Station	Latitude	Longitude	Location	Capacity	Note
Existing pumping stations						
1	Co Dien pumping station	21.110408°	105.794209°	Co Dien hamlet, Hai Boi commune, Dong Anh district		
	Hai Boi wastewater treatment station	21.112469°	105.795816°	Hai Boi commune, Dong Anh district		Close to Co Dien pumping station
2	Yen So pumping station	20.956622°	105.871123°	Yen So ward, Hoang Mai district	Capacity of 90 m^3/s, for water drainage on 7753 ha	Pumping station for water drainage for Southern Ha Noi; water pumping from To Lich river, Kim Nguu river, Lu river, Set river into the Red river
3	Dong My pumping station	20.923715°	105.880468°	Bac Ha hamlet, Dong My commune, Thanh Tri district	Capacity 35 m^3/s, for water drainage on 1950 ha; at present, the station is not much used.	Discharge gate of Dong My pumping station in Chanh Khuc village, Duyen Ha commune, Thanh Tri district
4	Bo Dau pumping station	20.792991°	105.915416°	Thong Nhat commune, Thuong Tin district	Capacity of 15 m3/s, for water drainage on 1150 ha	
5	Khai Thai pumping station	20.728513°	105.958010°	Khai Thai commune, Phu Xuyen district	Total capacity of this station and Yen Lenh station is 50 m^3/s for water drainage on 8672 ha	
Pumping station to be newly built according to the planning in Decision No 1590/QĐ-TTg						
1	Ngu Kien pumping station			Ngu Kien commune, Vinh Tuong district, Vinh Phuc province	Capacity of 100 m^3/s	
2	Nguyet Duc pumping station			Nguyet Duc commune, Yen Lac district, Vinh Phuc province	Capacity of 100 m^3/s	
3	Lien Mac pumping station			Thuy Phuong commune, Tu Liem district	Capacity of 170 m^3/s, for water drainage on 9200 ha	Pumping water from Nhue river into the Red river
4	Nam Thang Long pumping station			The location has not yet been determined.	Capacity of 9 m^3/s, for water drainage on 450 ha	
5	Tu Dinh pumping station			Tu Dinh, Long Bien ward, Long Bien district	Water drainage on 3500 ha	Water drainage in Long Bien district
6	Me So pumping			Me So commune, Van Giang	Water drainage on	Water drainage for Van Giang district, Hung

	station			district, Hung Yen province	3756 ha	Yen province
7	Nghi Xuyen pumping station			Nghi Xuyen, Chi Tan commune, Khoai Chau district, Hung Yen province	Water drainage on 13280 ha	Water drainage for Bac Hung Hai irrigation system

Specific location of stations for pumping water into the Red river is presented in Figure 5 below.

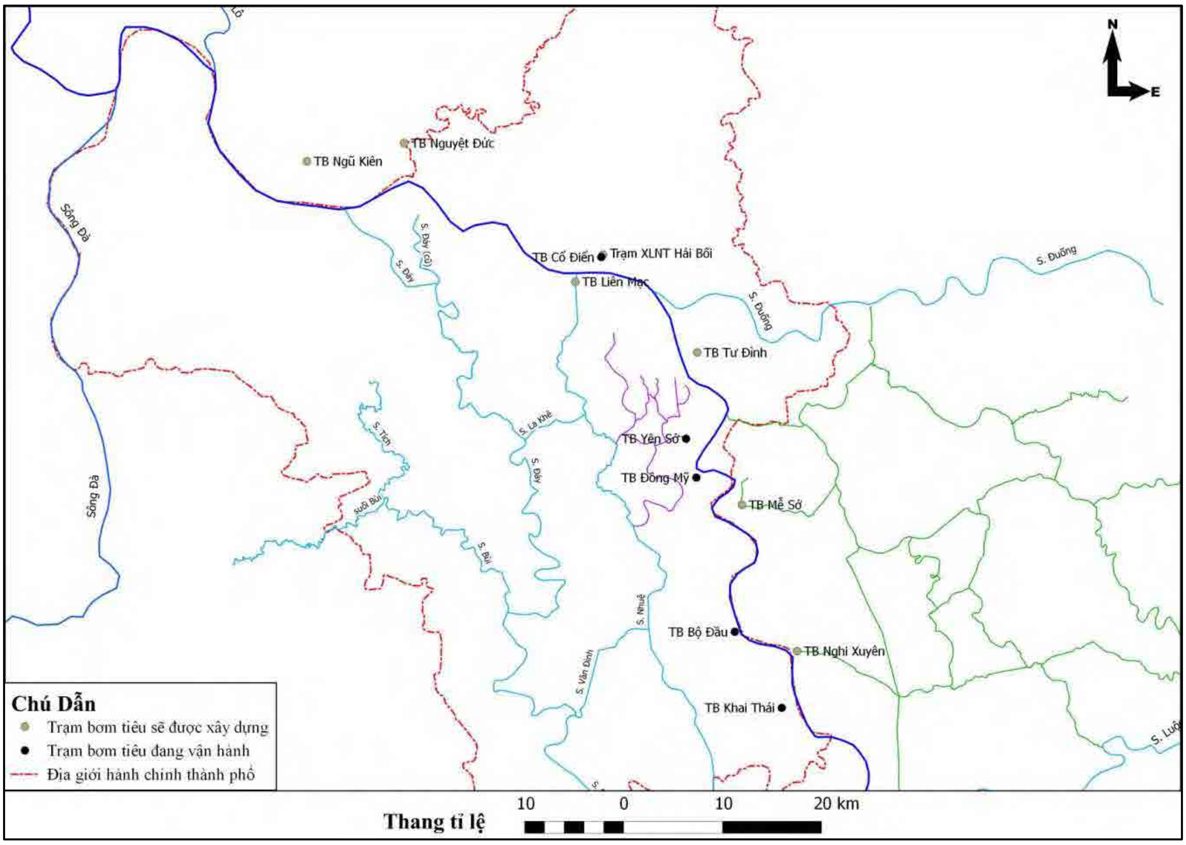


Figure 5: Location of pumping stations along the Red river in Ha Noi city

Pollution entities along the Red river

Along the Red river in Ha Noi city, industrial entities are likely to exert adverse effects on water quality along the Red river, especially riverside entities located in Viet Tri city, Phu Tho province and some entities located outside the dykes and harbors along the Red river. Table 3 lists entities with a high risk of pollution, affecting water quality of the Red river.

Table 3: List of entities with a high risk of polluting the Red river

No	Pollution source	Location	Description	Note
1	Lam Thao chemical and superphosphate	Lam Thao township, Lam		

	factory	Thao district, Phu Tho province		
2	Phu Tho ethanol production factory	Co Tiet commune, Tam Nong district, Phu Tho province		
3	Industrial Zone	Kinh Ke commune, Lam Thao district, Phu Tho province		
4	Sai Gon-Phu Tho beer factory	Thuong Nong commune, Tam Nong district, Phu Tho province		
5	Viet Tri chemical factory – detergent workshop	Tien Cat ward, Viet Tri city, Phu Tho province		
6	Viet Tri ceramics factory	Tien Cat ward, Viet Tri city, Phu Tho province		
7	Viet Tri chemical factory	Tho Son ward, Viet Tri city, Phu Tho province		
8	Viet Tri paper factory	Ben Got ward, Viet Tri city, Phu Tho province		
9	Viet Tri harbor	Ben Got ward, Viet Tri city, Phu Tho province		
10	Hung Thinh Phat steel plate factory	Bach Hac ward, Viet Tri city, Phu Tho province		
11	Son Tay harbor	Le Loi ward, Son Tay provincial town		
12	Ha Noi BTH transformer manufacturing factory	Thuong Cat commune, Tu Liem		
13	Tran Quang auto air conditioner production factory	Thuong Cat commune, Tu Liem district		
14	Thang Long Industrial Zone	Kim Chung commune, Vong La, Dai Mach, Dong Anh district		
15	Den ferry	Thanh Luong ward, Hai Ba Trung district		
16	Ha Noi harbor	Thanh Luong ward, Hai Ba Trung district		
17	Ha Noi ship building enterprise	Thanh Tri ward, Hoang Mai district		
18	Red river ship building factory	Tran Phu ward, Hoang Mai district		
19	Khuyen Luong harbor	Tran Phu ward, Yen So, Hoang Mai district		
20	Cattle feed processing factory	Yen So ward, Hoang Mai district		
21	Mitsui Thang Long steel structure company	Ninh So commune, Thuong Tin district		

Entities with a high potential of polluting the Red river water are shown in figure 6 below.

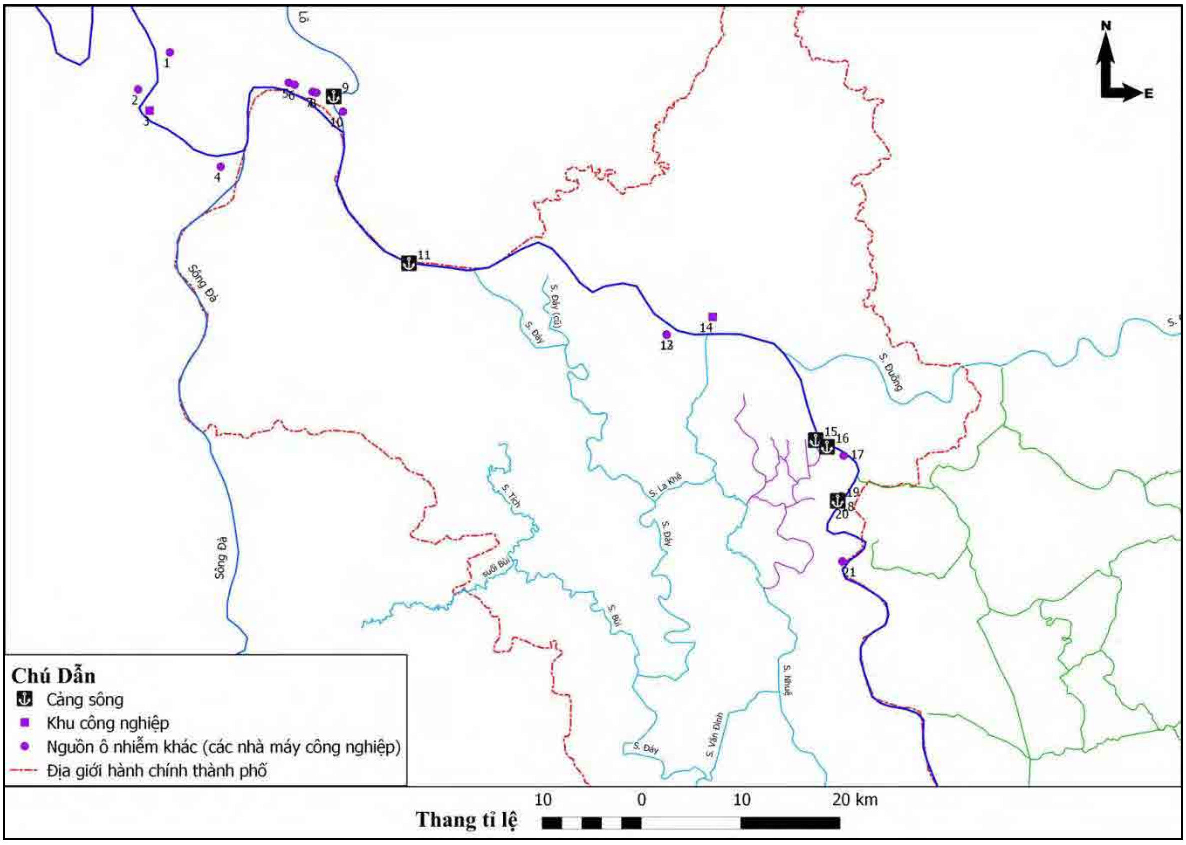


Figure 6: Map of entities with a high potential of pollution

In addition to the entities with a high potential of polluting the Red river water, industrial production entities and small-scale industry entities far from the Red river water and inside the dyke potentially affect river water quality though at a lower level. List of these potential pollution sources is presented in table 4.

Table 4: List of potential pollution sources along the Red river

No	Pollution sources	Location	Description	Note
1	Thuy Van industrial park	Thuy Van commune, Viet Tri city, Phu Tho province		
2	Tuynel brick plant of Hong Ha commune	Hong Ha commune, Dan Phuong district		
3	Craft village small-scale industrial zone of Lien Ha commune	Lien Ha commune, Dan Phuong district		
4	Ha Noi beer factory	Tien Phong commune, Me Linh district		
5	Nam Thang Long industrial zone	Thuy Phuong commune, Lien Mac, Tu Liem district		
6	Z133 factory	Ngoc Thuy ward, Long Bien district		
7	Duc Giang chemical factory	Thuong Thanh district, Long Bien district		

No	Pollution sources	Location	Description	Note
8	Duc Giang petroleum storehouse	Duc Giang ward, Long Bien district		
9	Duc Giang petroleum harbor	Thuong Thanh ward, Long Bien district		
10	Gia Lam railway station	Gia Thuy ward, Long Bien district		
11	Gia Lam airport	Phuc Dong ward, Long Bien district		
12	Sai Dong B Industrial Zone	Thach Ban ward, Long Bien district		
	Minh Khai Industrial Cluster – Vinh Tuy			
13	Minh Khai textile factory	Vinh Tuy ward, Hai Ba Trung district		
14	Hai Chau confectionery factory			
15	Vinh Tuy concrete company			
16	Nam Thang brick plant			
17	Thanh Tri ceramic plant	Thanh Tri ward, Hoang Mai district		
18	Bat Trang ceramic village	Bat Trang commune, Gia Lam district		
19	Kim Lan ceramic village	Kim Lan commune, Gia Lam district		
20	Brick plant	Thong Nhat commune, Thuong Tin district		
21	Van Diem sugar plant	Van Diem commune, Thuong Tin district		

3.4 Precipitation and river flow rate

Precipitation and river flow rate have great impacts on water quality in the river. When it rains, pollutants from land surface, sewer system, cultivation fields ... are washed away, running into the river, and therefore, increasing the concentration of some pollutants. In addition, when river flow rate increases, self-cleaning capacity of the river is improved, leading to changes in river water quality. Therefore, during the preparation of monitoring program/plan or sampling, it is necessary to consider the seasonal trends of the study area as well as related hydro- meteorological conditions .

Meteorological conditions

The climate in Ha Noi is typical for the Northern region which is characterized by humid monsoonal tropical climate (hot summer with much rain and cold winter with little rain). As Ha Noi is located in a tropical region, the city receives abundant solar radiation all the year round and high temperature. In addition, due to impacts of the sea, Ha Noi gets a fairly high humidity and rainfall, with 114 rainy days per year. Ha Noi has two distinct seasons: hot and cold ones. The hot season lasts from May to September, with much rain and mean temperature of 28.1 °C. Winter lasts from November to March of the next year with the average temperature of 18.6 °C. Mean annual precipitation is 1672 mm; the rainy season lasts from May to September; precipitation in 5 months of the rainy season represents 77.5% of the total precipitation of the year. The chart of monthly precipitation for years in Ha Noi station is presented in figure 7.

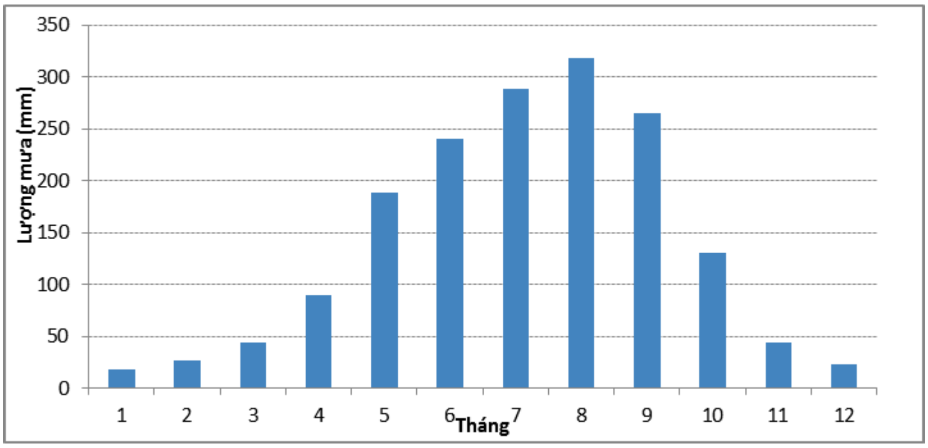


Figure 7: Mean precipitation over years (1898-2011) measured at Ha Noi station (*Source: Centre for Hydro- meteorological Documentation*)

<u>Red river hydrology</u>

List and location of hydrological stations in the rivers of Ha Noi city are presented in table 5. The Red river witnesses two hydrological stations while Da river has one hydrological station. These three stations will be considered for setting up monitoring points which are right at these stations so that river hydrological data can be used for analysis of river water quality.

Table 5: List of hydrological stations in Ha Noi

No	**Station**	**River**	**Latitude**	**Longitude**	**Location**
1	Trung Ha	Da	21°14'	105°20'	Thai Hoa commune – Ba Vi district
2	Son Tay	Red	21°09'	105°30'	Vien Son ward – Son Tay provincial town
3	Ha Noi	Red	21°01'	105°51'	Phuc Tan ward – Hoan Kiem district
4	Thuong Cat	Duong	21°04'	105°52'	Thuong Thanh ward – Long Bien district
5	Ba Tha	Day	20°48'	105°42'	Vien An commune – Ung Hoa district
6	Phu Cuong	Ca Lo	21°10'	105°54'	Thuy Loi hamlet –Thuy Lam commune – Dong Anh district

Hydrological regime of the Red river can be distinctly divided into two seasons: flooding season and dry season. Figure 8 below shows the chart of the Red river flow rate in Son Tay station and Ha Noi station for a long time (from 1988 to 2010 at Son Tay station and from 1988 to 2006 at Ha Noi station). In 1988, Hoa Binh power plant was put into operation and greatly affected the flows of Red river downstream; therefore, calculation related to Red river flows is normally made from this year.

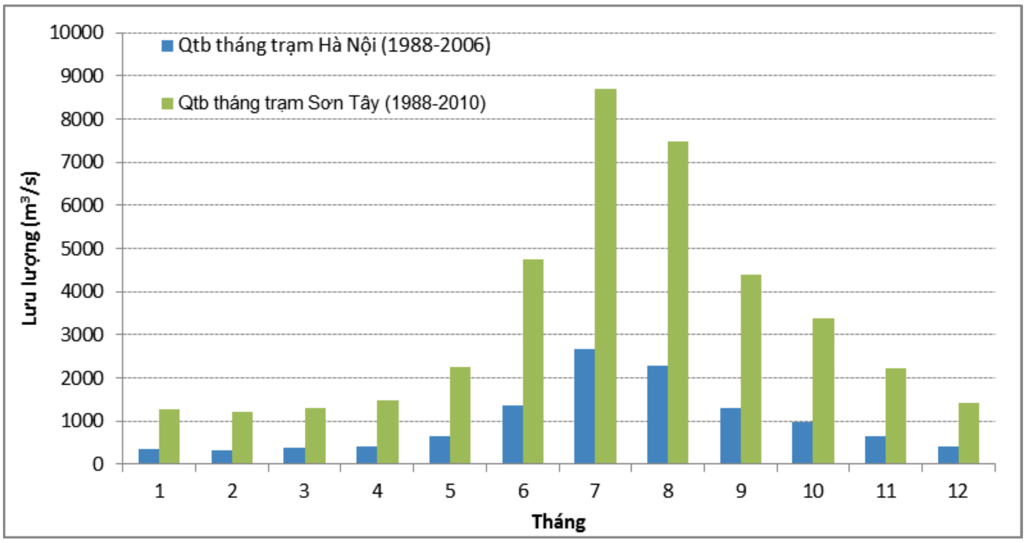


Figure 8: Mean annual flow rate of the Red river over years measured at Ha Noi station (1988-2006) and Son Tay (1988-2010) (*Source: Water Resource Management Department, MONRE*)

Flooding season

Flooding season normally covers months with a mean monthly discharge volume higher than a mean annual discharge volume. Floods occurring in the Red river downstream normally occur for five months from June to October. Discharge volume in the flooding season accounts for about 80% of total discharge volume of a year.

Three months with the largest discharge volume comprise July, August and September, being 50% more or less of the total discharge volume of a year. In Son Tay (in the Red river), the total of the three months with the largest volume accounts for 52.61%; in Ha Noi, the value is 51.92% and in Thuong Cat (Duong river) 49.86%.

July has the highest discharge volume, representing about over 18% of annual total. In the big river such as the Red river, the total in July in Ha Noi and in Son Tay represents 20.75% and 21.36% respectively. In Duong river in Thuong Cat, the value is 18.48%.

Da river, Thao river, and Lo river meet at Viet Tri provincial town, forming a main stream of the Red river that flows into the plain area and thereby creating a water body which is quickly concentrated and slowly drained. Along this river 64 km long from Viet Tri to Ha Noi, a big protective solid dyke is established due high water surface slope at 6 cm/km, the flooding water is severe. Flooding amplitude is 3-4 m and water level rise speed is 1-2m/hour. Time for maintaining flooding level which is above the 3rd alarming level lasts 10 days.

Dry season

Dry season in the Red river basin lasts from late November to May; November is the transitional month between flooding season and dry season. Discharge volume starts to reduce from October and markedly decrease from December to April, being the minimum in February and March in the main streams and big tributaries. In April and May, due to the presence of rainstorms, discharge volume starts to increase. In dry season months, precipitation represents 20 – 25% of the annual one, mainly focusing in November, April and May; from December to February, it is dry and rains slightly; in late March, drizzle occurs. From December to March, in-river flow mainly comes from underground water source. Dry season discharge volume represents only 20% of the annual total. In the Red river, the three driest months are January, February and March with the total discharge volume of more or less 10% of the annual total. In Son Tay and in Ha Noi, the figure is 9.75% and 10.06% respectively. February sees the lowest discharge volume with the total of over 2.9 - 3% of total annual discharge volume; the value in Ha Noi and Son Tay is 2.99% and 2.94% respectively. In Duong river, in Thuong Cat, the three driest months are February, March and April with the discharge volume of 8.24%.

4 Monitoring points

Principles for selection of monitoring points

Monitoring points are selected to:

(i) Understand about baseline data on river water quality and longitudinal trend of water quality

(ii) Supervise water quality at water intake stations

(iii) Supervise water quality in key pollution areas

To meet these objectives, monitoring location should be selected based on the following principles:

- Starting or ending point of the river in the province.
- The point upstream or downstream of the confluence of the river
- The point upstream or downstream of the water intake stations
- The point upstream or downstream of the discharge location of pollution source into the rivers or a pollution area through which the river flows.

  Based on these selection principles and characteristics of the Red river flowing through Ha Noi city as presented above (eg.: land use purposes, location of water intake station, wastewater discharge source, location of hydrological stations, …), the monitoring plan is designed, setting up 20 monitoring points in the Red river and 1 monitoring point in Da river. Monitoring points are described and defined in the figures below. Specific address and coordinates of each monitoring point, monitoring details and purposes of each monitoring points are described in table 6.

List of monitoring stations

Table 6: List of monitoring stations for Red river water quality

No	Station code	Station name	Coordinate (WGS-84)		Location	Description	Purposes of monitoring stations	Note
			Latitude	Longitude				
1	SH-1	Hong Da	21.249235°	105.344505°	Hong Da commune –Tam Nong district, Phu Tho province	In the middle of the river, 500 m downstream from the outlet of canal that runs through Sai Gon –Phu Tho beer factory, 1 km upstream from the confluence of Red river and Da river	Reference station (before the confluence; to understand water quality of the Red river before the Red river receives water from Da river)	**New monitoring station**
2	SH-2	Trung Ha	21.234743°	105.350556°	Trung Ha bridge – Thai Hoa commune–Ba Vi district (in Da river)	In the middle of Trung Ha bridge, 2 km upstream from the confluence of Red river and Da river, 90 m upstream from Trung Ha pumping station	Reference station (before the confluence; to understand water quality of Da river before it joins the Red river)	**New monitoring station, <u>or hydrological station</u>**
3	SH-3	Co Do	21.277426°	105.356738°	Co Do – Co Do commune –Ba Vi district	In the middle of the river opposite Co Do communal house, 3 km downstream from the confluence of the Red river and Da river	Confluence station (after the confluence; to understand water quality of the Red river after the confluence point)	Old monitoring station, NM19
4	SH-4	Phu Cuong	21.290197°	105.415298°	Phu Cuong –Ba Vi district	In the middle of the river, 3 km upstream from the confluence of the Red river and Lo river	Reference station (before the confluence; to understand water quality of the Red river before it receives water from Lo river); to check impacts of pollution sources from Viet Tri city.	**Moving old monitoring station NM21 *2km downstream*** (to check impacts of pollution from Viet Tri city)
5	SH-5	Chau Son	21.260597°	105.442796°	Hac Son hamlet –Chau Son commune –Ba Vi district	In the middle of the river, 1 km downstream from the confluence of the Red river and Lo river, opposite Dai Dinh pumping station on the other side of the river.	Confluence station (after the confluence; to understand water quality of the Red river after it receives water from Lo river); to check if the river water quality is suitable for agricultural activities (river water is provided for agricultural activities through Dai Dinh pumping station)	Old monitoring station NM22
6	SH-6	Son Tay	21.157530°	105.502990°	Son Tay harbor – Phu Thinh	In the middle of the river opposite Son Tay harbor, 2 km	To check if river water quality is relevant for agricultural activities (river water is supplied	Old monitoring station, NM23, <u>or hydrological</u>

No	Station code	Station name	Coordinate (WGS-84)		Location	Description	Purposes of monitoring stations	Note
			Latitude	Longitude				
					ward –Son Tay provincial town	downstream from Vinh Thinh ferry and 700 m upstream from Phu Sa pumping station	through Phu Sa pumping station); to study water quality trend of the Red river; to check impacts of pollution from Son Tay provincial town	station
7	SH-7	Cam Dinh	21.151481°	105.553618°	Cam Dinh hamlet –Cam Dinh village – Phuc Tho district	In the middle of the river, 500 m upstream from Cam Dinh gate, 1.5 km upstream from Xuan Phu pumping station	To check if the river water quality is suitable for agricultural activities (river water is supplied through Cam Dinh gate and Xuan Phu pumping station); to understand the trend of Red river water quality	Old monitoring station, NM24
8	SH-8	Tho An	21.152706°	105.647362°	Tho An ferry harbor– Tho An commune – Dan Phuong district	In the middle of the river on Tho An ferry route – Chu Phan	To check if the river water quality is suitable for agricultural activities (river water is supplied through Thanh Diem pumping station); to understand the trend of Red river water quality	Old monitoring station, NM28
9	SH-9	Lien Ha	21.116497°	105.720300°	Lien Ha commune – Dan Phuong district	In the middle of the river, opposite Lien Ha communal house, 100 m upstream from Dan Hoai pumping station	To check if the river water quality is suitable for agricultural activities (river water is supplied through Dan Hoai pumping station); to understand the trend of Red river water quality	Old monitoring station, NM33
10	SH-10	Lien Mac	21.095214°	105.766543°	Hoang Xa hamlet – Lien Mac commune – Tu Liem district	In the middle of the river, opposite Hoang temple –Hoang Xa hamlet, 500 m upstream from Lien Mac gate, downstream of Lien Mac harbor	To check if the river water quality is suitable for agricultural activities (river water is supplied through Lien Mac gate, Ap Bac pumping station); to understand the trend of Red river water quality; to check impacts of Nhue river water pumped into the Red river	**Moving old monitoring station NM2 1 km upstream** (to check the quality of water supplied through Lien Mac gate)
11	SH-11	Nhat Tan	21.089035°	105.828544°	Nhat Tan ward – Tay Ho district	In the middle of the river opposite Tam Xa sandy flat, going by vehicle from Au Co road to Nhat Tan border gate (close to Nhat Tan market) 1km downstream from Nhat Tan bridge, 2 km upstream from the inlet of Duong river.	Reference station (before the branching point; to understand water quality of the Red river before it shares its water with Duong river); to study the trend of water quality of the Red river; to check possible impacts of pollution from Thang Long Industrial Park, Lien Mac and Co Dien pumping stations, on Red river water quality.	**Moving old monitoring station NM5 1.5 km upstream** (to supervise water quality before the branching point, the station is not too far to control potential upstream pollution sources; to ensure accessibility to

No	Station code	Station name	Coordinate (WGS-84)		Location	Description	Purposes of monitoring stations	Note
			Latitude	Longitude				
								sampling location
12	SH-12	Long Bien	21.043883°	105.861186°	Long Bien bridge –Phuc Tan ward –Hoan Kiem district	In the middle of the main flow, 30 m downstream from Long Bien bridge foot, being accessible by walking to Lane 195 Hong Ha and then along the river bank	To study the trend of Red river water quality	Old monitoring station, NM6, or hydrological station
13	SH-13	Chuong Duong Do	21.020360°	105.867190°	Chuong Duong Do - Hoan Kiem district	In the middle of the river, opposite Lane 695, Bach Dang road, 2 km downstream of Chuong Duong bridge	To study the trend of the Red river water quality; to check river water quality at the point after the two river flows, which run through Phuc Xa mud flat, join; in the future, it is possible to check pollution impacts (of Tu Dinh pumping station (Long Bien district)) on river water quality.	Old monitoring station, NM8
14	SH-14	Thanh Tri	20.998039°	105.895160°	Thanh Tri ward –Hoang Mai district	In the middle of the river, opposite Thanh Tri ceramic factory, 1.9 km downstream from Vinh Tuy bridge, 800 m upstream from Thanh Tri bridge	To check pollution impacts of Pha Den harbor on river water quality.	Old monitoring station, NM11
15	SH-15	Linh Nam	20.981078°	105.910187°	Linh Nam ward –Hoang Mai district	In the middle of the river, 1.6 km downstream from Thanh Tri bridge, 500 m upstream from Bac Hung Hai river mouth, opposite Giang Cao temple (Bat Trang commune), being accessible by vehicles by going toward the river bank at the joint section between Thanh Tri bridge and Huu Hong dyke	To check if river water quality is suitable for agricultural activities (river water is supplied for Bac Hung Hai irrigation system through Xuan Quan gate); to check pollution impacts of Ha Noi ship building enterprise on river water quality.	Old monitoring station, NM14
16	SH-16	Tran Phu	20.948915°	105.888287°	Tran Phu ward –Hoang Mai district	In the middle of the river, 1 km downstream from Khuyen Luong harbor, 350 m upstream from drainage canal of Yen So pumping station	To check pollution impacts of Khuyen Luong harbor and surrounding industrial factories on river water quality	Old monitoring station, NM16
17	SH-17	Duyen Ha	20.929890°	105.882951°	Chanh Khuc	In the middle of the river, 1.7	To check pollution impacts of Yen So	Old monitoring station,

No	Station code	Station name	Coordinate (WGS-84)		Location	Description	Purposes of monitoring stations	Note
			Latitude	Longitude				
					village–Duyen Ha commune – Thanh Tri district	km downstream from drainage canal of Yen So pumping station	pumping station on river water quality	NM17
18	SH-18	Van Phuc	20.921587°	105.915607°	Hamlet 2 –Van Phuc commune –Thanh Tri district	In the middle of the river from sandy flat of Van Phuc commune, 3.5 km downstream of drainage canal of Dong My pumping station, opposite Lien Nghia commune, Van Giang district, 2.5 km upstream from Duong ferry/boat station	To check pollution impacts of Dong My pumping station on river water quality; to check if river water quality is suitable for agricultural activities (river water is supplied through Lien Nghia gate which shall be constructed in the future for Bac Hung Hai irrigation system)	**Moving old monitoring station NM18 2.5 km upstream** (to check the suitability of water use purpose)
19	SH-19	Ninh So	20.895343°	105.894923°	Ngang ferry station – Xam Duong hamlet – Ninh So commune - Thuong Tin district	In the middle of the river from Ngang ferry station, 900 m downstream from Mitsui Thang Long steel factory, 400 m upstream from Hong Van pumping station	To check if river water quality is suitable for agricultural activities (river water is supplied through Hong Van pumping station); to check pollution impacts of Mitsui Thang Long factory on river water quality; to understand river water quality trend	Old monitoring station, NM34
20	SH-20	Van Nhan	20.786882°	105.927553°	Van Nhan commune –Phu Xuyen district	In the middle of the river from ferry station of Phu Minh township – Dong Ninh ferry station, 1 km upstream from Thuy Phu pumping station	To check if river water quality is suitable for agricultural activities (river water is supplied through Thuy Phu pumping station and through Nghi Xuyen gate that is located further and will be built in the future); to understand the trend of river water quality; to check pollution sources possibly from Phu Minh township.	**Moving old monitoring station NM37 3.5 km downstream** (to check the suitability of water use purpose)
21	SH-21	Quang Lang	20.703812°	105.995245°	Mai Xa hamlet – Quang Lang commune – Phu Xuyen district	In the middle of the river from the ferry station of Quang Lang commune, the end of the Red river in Ha Noi	Boundary monitoring station (the end of the Red river in Ha Noi); to understand the trend of river water quality	Old monitoring station, NM40

Fig 9 and 10 below present detailed description of monitoring points in the monitoring plan for Red river water quality. Location of monitoring points in a relation with location of water intake points, pumping stations, and pollution sources are presented in detail in figures of P-1 to P-3 in the attatched appendixes.

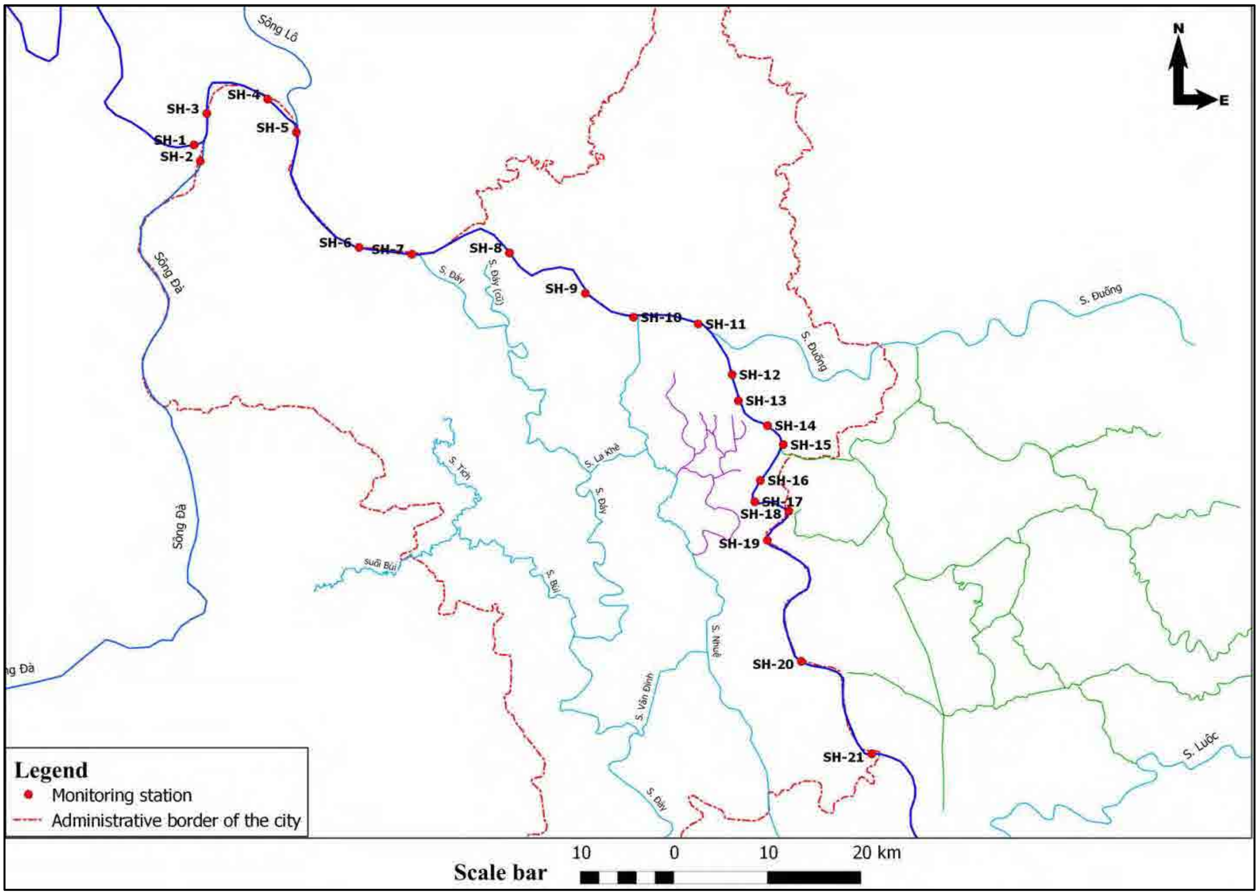


Figure 9: Location of monitoring points in the monitoring plan for Red river water quality.

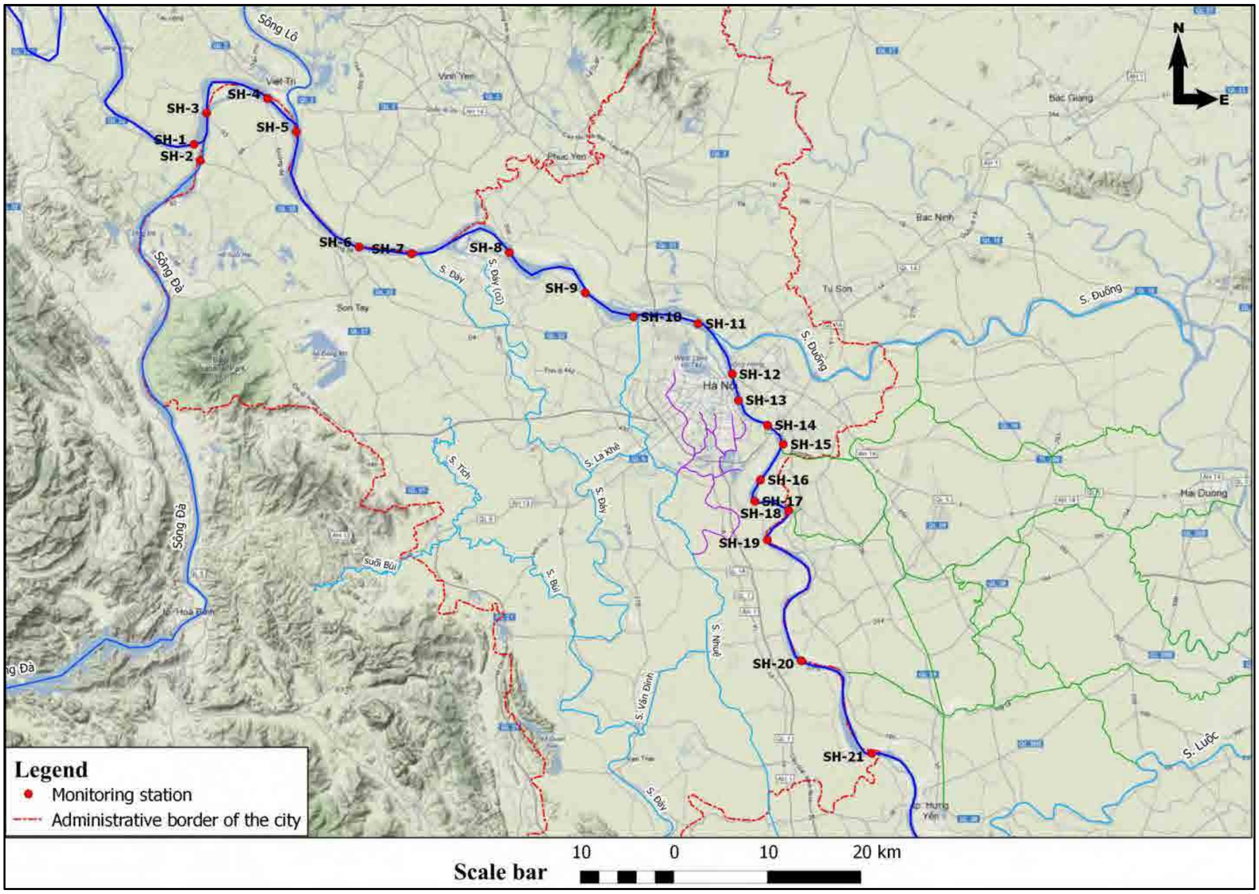


Figure 10: Monitoring points in the monitoring plan for Red river water quality on a topographic background.

5 Monitoring parameters

6 Monitoring time and frequency

Monitoring frequency: once/quarter (4 times/year)

Sampling time: February, April, July and October.

According to Circular 29/2011/TT-BTNMT of Ministry of Natural Resources and Environment, the minimum impact monitoring frequency is required to be once/quarter. Based on data on river flow rate, precipitation chart in Ha Noi and guidance of Circular 29, frequency of Red river monitoring is suggested to be four times/year (sampling twice in rainy season and twice in dry season). Specifically, sampling time is suggested to be in February (quarter I), April (quarter II), July (quarter III), and October (quarter IV). Sampling can be conducted in October at the latest in the fourth quarter as the remaining time of the year is used for finalizing the analysis and writing quarterly and yearly reports. Therefore, sampling is done in dry season (in February and April) and in rainy season (in July and October). April and October are in late dry and rainy seasons respectively. February and July are in the middle of dry and rainy seasons respectively. Such selection of monitoring frequency and time is aimed to study seasonal impacts on river water quality.

7 Preparing a monitoring plan

7.1 Human resources for monitoring work

7.2 Organizations and individuals involved in coordinating the monitoring work

7.3 List of equipment, tools and chemicals

7.4 Protection equipment/facilities

7.5 Sampling methods

7.6 Analysis methods in laboratories

7.7 QA/QC implementation plan

8 Data processing and reporting

8.1 Data processing

8.2 Reporting

9 Budget for implementation of environmental monitoring plan

Appendixes

Map of monitoring stations in a relation with water intake stations and pollution sources along the Red river.

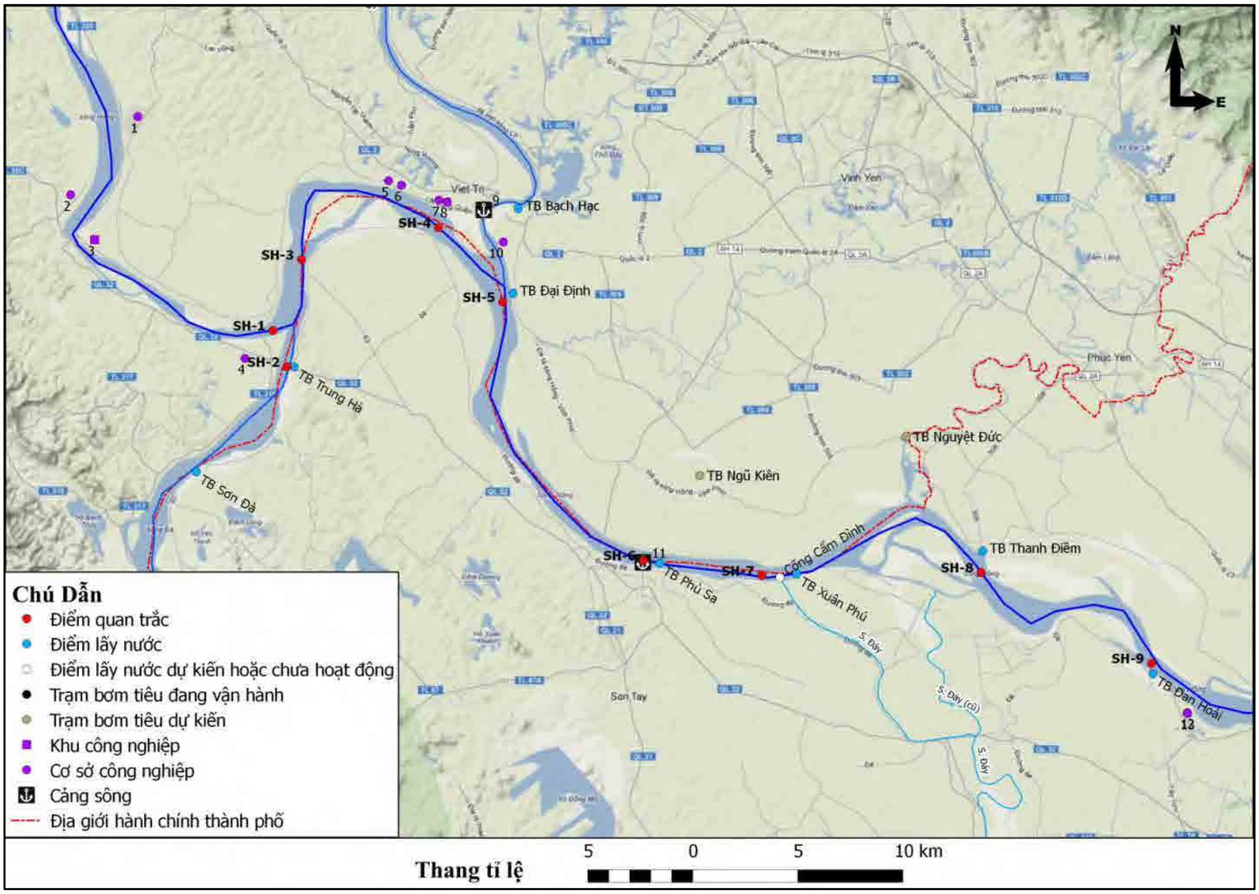


Fig. P-1: Monitoring points from SH-1 to SH-9.

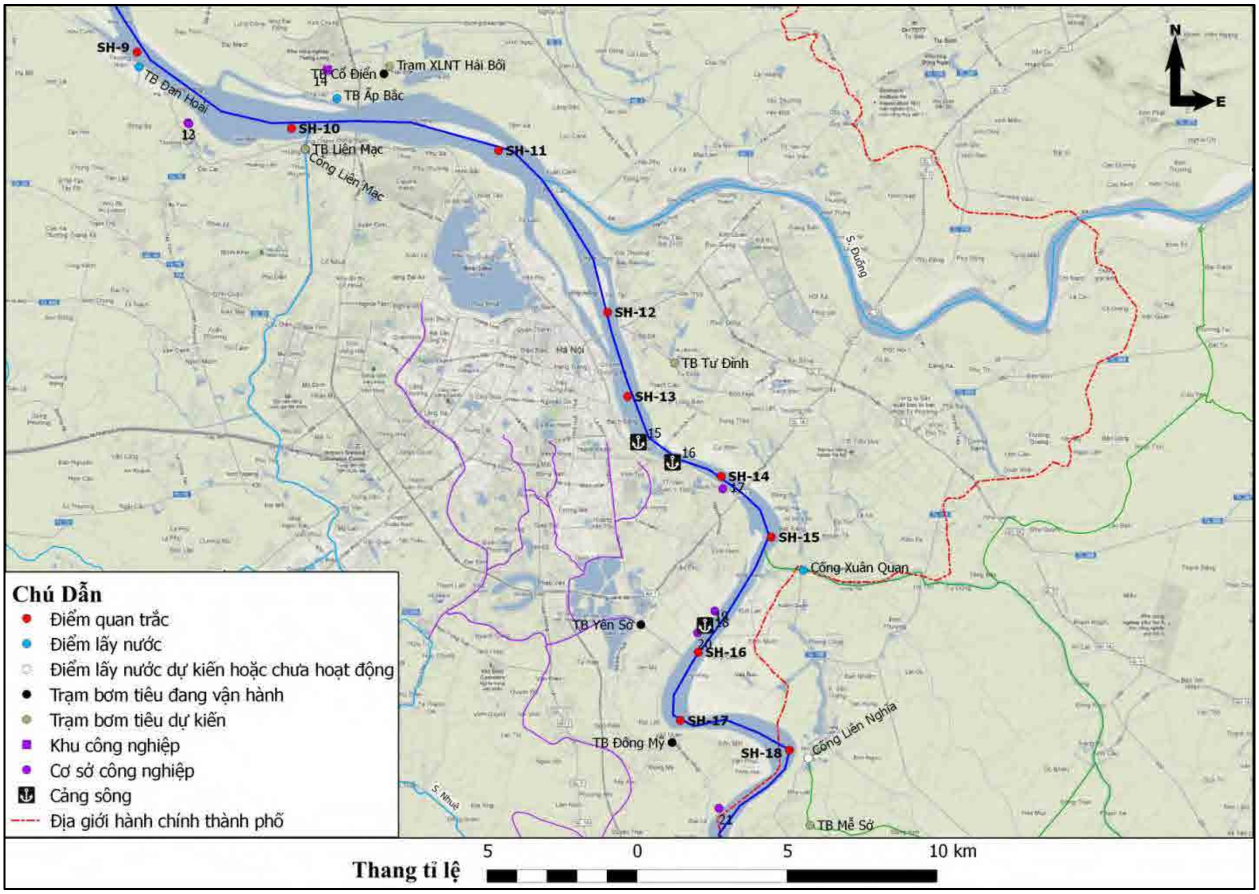


Fig. P-2: Monitoring points from SH-10 to SH-18.

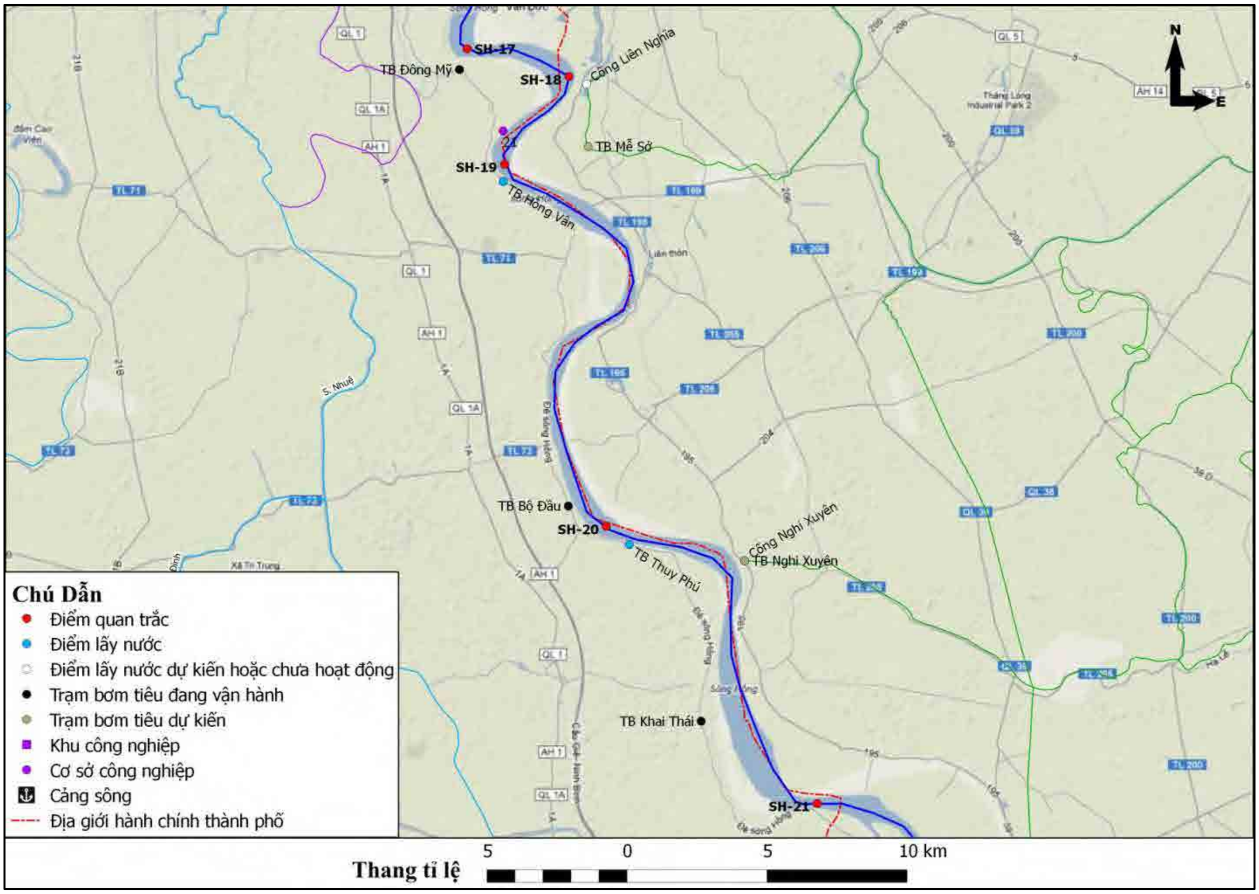


Fig. P-3: Monitoring points from SH-19 to SH-21.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SOCIALIST REPUBLIC OF VIET NAM

MINISTRY OF NATURAL RESOURCES & ENVIRONMENT

The Project
for
Strengthening Capacity of Water Environmental Management
in Vietnam

DQO Based Water Quality Monitoring Plan for

[Hai Phong, Re river]

Table of contents

CHAPTER 1 INTRODUCTION

1.1 Introduction

Systematic water quality monitoring in Vietnam is a relatively new activity and the national strategy for monitoring was set out by the Ministry of Natural Resources and Environment (MONRE) through the publishing of Decision No. 16/2007/QD-TTg of January 29, 2007, Approving the General Planning on the National Network of Natural Resources and Environment Observation.

The Master Plan for the years up to 2020, approved by the Prime Minister together with his January 29 Decision, aims to build a comprehensive, advanced and modern national network of natural resource and environment observation stations, meeting the demand for basic information and data on the environment, water resources and hydrometeorology.

The network is also expected to assist effectively the treatment of environmental pollution, the forecast, warning, prevention and mitigation of damage caused by natural disasters, for the strong and sustainable national socio-economic development.

The specific objectives set for the years 2007-10 were to:

- Reorganize the management and administration apparatus and train more observers;
- Amend and make comprehensive observation regulations, processes and criteria;
- Consolidate and modernize, step by step, existing natural resource and environment observation stations; and
- Build and put into operation at least one-third of the proposed stations.

For the period 2011-15 period the objectives are to:

- Continue consolidating and modernizing existing observation stations;
- Build and put to operation at least half of the remaining stations; and
- Upgrade the natural resource and environment database.

For the final period, 2016-20, the objectives are to:

- Complete the building of, and put to efficient operation, all observation stations under the Plan;
- Raise the capability of observers, technicians and managers to satisfy the requirements of the national network of natural resource and environment stations.

The major tasks to be undertaken which will enable the implementation of the Master Plan include:

- To prepare and issue legal documents, econo-technical processes, regulations and norms related to the observation, collection, management and supply of information and data on natural resources and environment according to uniform standards to be applied nationwide;
- To promulgate more preferential policies to encourage persons engaged in natural resource and environment observation and survey, especially those working in deep-lying, remote,

border and island areas;

- To standardize the profession of natural resources and environment observers;
- To step up scientific research, develop and apply advanced technologies, and enhance human resource training; and
- To expand and enhance international cooperation in the domain of natural resource and environment observation.

The implementation of the Master Plan will be effected by MONRE at the National level and the individual DONRE at the Provincial Level. At the National level the monitoring will focus on trans-national boundary water quality, and at provincial boundaries. At the provincial level the DONRE will focus on strategic locations within the province.

At the present time the details of the provincial Water Quality Monitoring Plans are prepared by a team of experts at the request of the Peoples' Committees. The plans are circulated for comment and revised and finally approved by the Peoples' Committees. The respective DONRE will subsequently implement the approved monitoring program.

1.2 Purpose of this document

The purpose of this document is to define the basis for the monitoring carried out at Provincial level by *Hai Phong Centre for Environmental Monitoring, Hai Phong DONRE*. The document has been compiled as part of a training workshop to develop the capacity of the DONRE staff for the design and implementation of monitoring plans and programs. The workshop was part of the JICA funded Project for Strengthening Capacity of water Environmental Management in Vietnam carried out in 2011/2013. The document defines the environmental problems relating to water quality in the province, the purpose of the monitoring to be carried out, references all the methodologies to be used during the monitoring, the rational for selecting the contaminants to be measured and the reasons for the selected sampling stations. It also defines the statistical test to be used to interpret the data and what procedures will be used to handle concentrations which are below the Limit of Detection and how to identify rogue or outlier values.

By drawing all of the above information into one document it provides immediate access to all of the fundamental assumptions made at the planning stage and a reference to all of the technical procedures used during the monitoring process.

1.3 The DQO Process

The DQO Process is a series of logical steps that guides project managers or scientific staff in the planning of resource-effective collection of environmental data. It can be used to plan the compiling of existing data and the collection of data into the future as in the case of water quality monitoring

The process is flexible and iterative, and can be applied to both the decision-making process (e.g., compliance/non-compliance with a standard) and estimation (e.g., determining the mean concentration level of a contaminant in the environment).

The DQO process is described in full in Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. In August 2011 the staff of the DONRE were given a 1-day introduction to the DQO process as part of the training program.

The DQO Process is used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO Process leads to efficient and effective expenditure of resources; agreement between stakeholders on the type, quality, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project.

CHAPTER 2 OBJECTIVES AND RESOURCES FOR THE MONITORING PLAN

2.1 Status of water quality in Re river

Importance of Re river

Small rivers which include Re, Gia, Da Do and Chanh rivers are major surface water sources for domestic, agricultural and industrial activities in Hai Phong city. Re river provides about 42 million m^3 of raw water per year for An Duong drinking water treatment plant, meeting the water demand of over 1 million residents in inner city area, or around 60% of the city population. This is also a fresh water irrigation source for 10 thousand ha of cultivation crops in An Duong district and some wards of Hong Bang district.

Status of water quality and pollution causes

Lying in the downstream of rivers and in coastal estuarine area, most of rivers in Hai Phong are directly or indirectly influenced by tides which results in salt intrusion further inland. According to the statistical data of the Northeast hydro-meteorological station, over the past years, due to a decrease in river water volume of Thai Binh and Red river system in dry season, salt intrusion has been widely expanded, being close to the boundary between Hai Phong and Hai Duong provinces.

According to the monitoring results of Re river in 2011 collected from Hai Phong Centre for Environmental Monitoring (HACEM), Re river water was polluted by organic substances, ammonium, heavy metals, etc... with a high concentration exceeding the allowable level (column A2 in QCVN 08:2008/BTNMT). Specifically, in Phung Duong sub-hamlet (Dinh Ngo hamlet, Hong Phong commune), total suspended solid (TSS) was 2.3 times higher than column A2 (June), nitrite 1.3 times higher (December), ammonium 3.8 times (December), phenol 5.8 times higher (June), coliform 2.6 times higher (August), and Fe 1.4 times (August). In Bac Ha (Bac Son commune), near Vat Cach water factory, TSS was 2 times higher than the standard level (April), BOD & COD 1.5 times higher (June), nitrite 1.8 times (December), ammonium 10 times higher (December), phenol 12.2 times higher (August), coliform 3.2 times higher (April), Fe 2.2 times higher (April) than the standard level. In Luong Quy hamlet (Le Loi commune), TSS was twice higher (August), nitrite 1.6 time higher (December), ammonium 8.7 times higher (December), phenol 4.4 times higher (October), Fe 2.3 times higher (August), mercury 1.7 times higher (April) than the standard level. In group 3 area, An Duong township (near Re bridge), TSS was 1.9 times higher (August), BOD 1.2 time higher (October), nitrite 2.3 times higher (December), ammonium 4.3 times higher (December), phenol 3.2 times higher (October), coliform 1.6 times higher (August), mercury 1.5 times higher (April) than the standard level. In Van Tra hamlet (An Dong commune), TSS was found to be 2.4 times higher (August), nitrite 1.9 times higher (December), ammonium 1.5 times higher (December), phenol 3.4 times higher (April), coliform 1.6 times higher (October and December), and mercury 1.8 times higher (April) than the standard level. Water sample collected from Cai Tat sewer showed TSS being 2 times higher (August), nitrite 2.6 times higher (December), ammonium 9.9 times higher (December), phenol 10.6 times higher (April), and mercury 1.6 times higher (April) than the standard level.

River water pollution has increased due to wastewater discharge from rice field, especially the presence of residual pesticides used in agricultural production and wastes from industrial and urban zones in upstream areas of rivers in Thai Binh river and Red river system. In the context of the city development, a series of new industrial factories and entertainment areas (golf courses) have been developed; wastewater and wastes from existing cultivation fields and cemeteries along the river side and expanded concentrated residential areas in the river basin are directly released into rivers that are domestic water supply sources for the city (Gia river, Re river, Da Do river adn Chanh river). These discharge sources, if not timely and well managed, will be a major cause of quality degradation of domestic water sources of the city.

Necessity of a monitoring plan

Therefore, regular monitoring for quality assessment of domestic water supply sources of the city is of great importance and cruciality with a view to taking timely control of changes in water source quality, especially pollution issues so as to provide warnings and orientations for water source protection.

2.2 Overall information on the monitoring plan

2.2.1 Objectives of the monitoring plan

The monitoring plan for Re river basin in Hai Phong city is designed to reply to the questions in priority order as follows:

(i) Is water quality in Re river suitable to the water use requirements specified in QCVN?

(ii) Are there longitudinal changes in river water quality and how is the change trend?

(iii) Do highly potential pollution sources in Re river basin exert impacts on the river water quality?

(iv) Does water quality temporally get worse (through years)?

(v) Do and how do meteorological factors and seasons affect water quality?

2.2.2 Type of monitoring and scope of the monitoring plan

(1) Type of monitoring

Accroding to Circular 29/2011/TT-BTNMT, there are two types of monitoring including baseline environmental monitoring and impact environmental monitoring. As such, the monitoring plan for Re river water quality follows impact environmental monitoring types.

Target population of the monitoring plan is surface water of Re river.

(2) Spatial scope

The monitoring plan is expected to be conducted in the entire Re river in Hai Phong city: from the junction of Dau, Ha Nhuan and Bang Lai rivers in Le Thien commune, An Duong district to Cai Tat gate in An Dong commune, An Duong district.

(3) Deadline for the monitoring plan

The monitoring plan is managed on a yearly basis. The starting date of the monitoring plan is 1st January and the end date is 31st December of a year. The plan is summed up in an annual report and submitted in early time of the next year (15th January).

2.2.3 Composition of the monitoring planning team

The monitoring planning team is composed of members from Environmental Monitoring &Analysis Division (EMAD) – Hai Phong Centre for Environmental Monitoring (HACEM). The team numbers 5 people, including one team leader and 4 members, two of whom are in charge of monitoring and the other two members in charge of analysis work. List and tasks of team members are shown in table 2.1.

Table 2.1: List of members in planning team

Name	Position	Responsibility	Contact
Khong Minh Tien	Head, EMAD	Team leader	0983454398
Le Tien Thanh	Monitoring staff	Team member	0915098085
Nguyen Duy Toan	Monitoring staff	Team member	0988226005
Vu Tu Linh	Analysis staff	Team member	0983618483
Nguyen Thi Hai Au	Analysis staff	Team member	0984144438

2.3 Resources for the monitoring plan

2.3.1 Budget for monitoring activities

Budget used for the monitoring plan for Re river is briefly presented in table 2.2 below.

Table 2.2: Budget for monitoring activities of the monitoring plan in Re river

Monitoring activity	Details	Cost
Survey for selection of monitoring sites	• Travelling means • Allowance for involved staff	1,825,000
Sampling	• Travelling means • Sampling tools, materials, records • Allowance for involved staff	30,138,000
Sample analysis	Analysis at HACEM laboratory	130,080,000
	Outsourced sample analysis	1,200,000
Synthesis and annual reporting		12,000,000
Total		**175,243,000**

2.3.2 Tasks and qualifications/background of monitoring staff

The monitoring plan for Re river is implemented by Environmental Monitoring and Analysis Division (EMAD)– Hai Phong Centre for Environmental Monitoring (HACEM). EMAD includes one head in charge of general management of monitoring & analysis activities, 7 monitoring officials and 9 analysis officials. Their specific information and tasks/skills are detailed in table 2.3.

Table 2.3: Tasks and background of monitoring staff at EMAD

Section	Position	Name	Tasks/skills
	Head	Khong Minh Tien	General management of monitoring & analysis activities
Monitoring	Official	Le Tien Thanh	Sampling
	Official	Tran Quoc Huy	Driving, sampling
	Official	Vu Duc Toan	Sampling
	Official	Pham Trung Tuyen	Sampling
	Official	Nguyen Duy Toan	Sampling
	Official	Hoang Thanh Binh	Sampling
	Official	Pham Duy Duong	Sampling
Analysis	Deputy head	Nguyen Tien Tung	Management of analysis group; analysis of heavy metal, oil & grease
	Official	Vu Tu Linh	Analysis of BOD, COD, TSS, TDS, reporting
	Official	Nguyen Thi Nhu Quynh	Analysis of ammonium, NO_3^-, NO_2^-
	Official	Nguyen Thi Hai Au	Analysis of heavy metal, phenol
	Official	Nguyen Van Tiep	Analysis of heavy metal
	Official	Tran Ngoc Long	Analysis of total N, SO_4^{2-}
	Official	Tran Thi Minh Huyen	Analysis of heavy metal, total P, PO_4^{3-}
	Official	Ha Thi Hang	Analysis of sulphide, chloride
	Official	Tran Thi Thu Thuy	Coliform analysis

2.3.3 Commitments of EMAD staff to other activities

In addition to participation in three monitoring plans (air quality monitoring, water quality monitoring in three rivers, monitoring in canals, lakes, discharge gates in inner areas and dump site), the staff of EMAD under HACEM also engage in:

- Inspection/check and monitoring activities of DONRE when requested.
- Providing environmentally scientific and technological services for interested organizations and individuals.

Table 2.4 provide a list of some activities involved by HACEM staff in 2013.

Table 2.4: Time table for other activities of HACEM staff

Activity	Participants	Time	Note
Tet holiday	All	From 9th /Feb. to 17th /Feb.	
World Environment Day	Monitoring staff (7 people)	5/June	
QA/QC training	Analysis staff (9 people)	5-10/March	
JICA project training	All (17 people)	4 courses/year, 3 days /course	
Environmental awareness raising events	All (17 people)	2 events/year, 1 day/event	

2.3.4 Field and laboratory equipment

(1) Field equipment

Field sampling and measurement equipment available at HACEM can be seen in table 2.5.

Table 2.5: List of field equipment

No	Analysis equipment	Manufacturer/Origin/Model	Quantity	Specifications
1	Horizontal water sampler	Fieldmaster (USA)	01	
2	Horizontal water sampler	Willco (USA)	01	
3	Vertical water sampler	Wilco beta (USA)	01	
4	Vertical sampling tool (glass flask)	Japan	01	
5	Automatic water sampler	MANNIG (USA)	01	
6	String for water sampling	Viet Nam	01	
7	Stick for water sampling	Viet Nam	01	
8	Multi-parameter meter	Horiba (Japan) U52	01	Temperature, pH, DO, salinity, conductivity, turbidity
9	Ultrasonic open channel flow meter	USA	01	
10	Flow velocity meter	Global Water (USA)	01	
11	Satellite positioning instrument	GPS 78 (USA)	01	

(2) Laboratory equipment

List of laboratory equipment available at HACEM is shown in table 2.6 below.

Table 2.6: List of HACEM's laboratory equipment

No	Analysis equipment	Manufacturer/Origin/Model	Qun't	Specifications
1	Atomic absorption spectrometer	Shimadzu (Japan) AA-7000 F/AAC	01	Two atomization systems: flame and graphite furnace. Accompanied cold vapor generation set (for measuring Hg) & hydride vapor generation set (for measuring As) Measured elements: Al, As, Se, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Ni, Pd, Pt, Sn, Zn
2	Spectrophotometer	Hach (USA) DR2800	01	
3	Spectrophotometer	Hach (USA) DR4000U	01	
4	Spectrophotometer	Hach (USA) DR2010	01	
5	Polarography analysis system	(Viet Nam) CPA-HH3		
6	Thermo hygrometer (mechanical)	China	01	
7	Digital thermo hygrometer	Japan	01	

No	Analysis equipment	Manufacturer/Origin/Model	Qun't	Specifications
8	pH meter	Hach (USA)	01	
9	Meter for pH, temperature	Hach (USA) EC10	01	
10	pH meter	Hach (USA) EC30	01	
11	Meter for pH, conductivity & temperature	Hach (USA) EC40	01	
12	Conductivity meter	Hach (USA) CO150	01	
13	DO meter	Hach (USA) DO175	01	
14	Dissolved oxygen meter	Toa DKK (Japan)	01	
15	DO meter	YSI (USA) 52CE	01	
16	Turbidity meter	Hach (USA) DR2100N	01	
17	Oil analyzer	HORIBA (Japan) OCMA-350	01	Analysis based on infrared spectroscopy. Measurement range: 0-200 mg/l Resolution: 0.1 mg/l (from 0 to 99.9 mg/L); 1 mg/L (from 100 to 200 mg/L)
18	Kejdahl digester	VELP (Italy) DK20	01	
19	COD reactor	Hach (USA) 45600	01	
20	COD reactor	Hach (USA) DRB200	01	
21	Optical microscope	Unitro (Japan) FSB	01	
22	Colony counter	WTW (Germany) BZG30	01	
23	Analytical balance	Sartorius (Germany) BP210S	01	
24	Technical balance	Sartorius (Germany) BP1200	01	
25	Silicagel dessicator	China	01	
26	Mixer (Vortex)	Thermolyne (USA) Maxi Mix II	01	
27	Magnetic stirrer	Jenway (ENGLAND) 1002	01	
28	Heating and magnetic stirrer	Jenway (ENGLAND) 1000	01	
29	Heating plate	Hach (USA)	01	
30	Ultrasonic bath	Geneq (Canada) 550D	01	
31	Water distillation instrument	Sanyo (Japan) WSCO44.MH3.4	01	
32	Centrifuge	IEC (USA) HN-SII	01	
33	Vacuum pump	Gelman-Gast (USA) DOAP184-BN	01	
34	Blender	Philips (Netherland) HR1721	01	
35	Drying oven	Memmet (Germany) ULM400	01	
36	Furnace	Gollenkamp (ENGLAND)	01	

No	Analysis equipment	Manufacturer/Origin/Model	Qun't	Specifications
37	Water bath	Shellab 1227.2E	01	
38	Water bath	Shellab 1225 PO	01	
39	Autoclave	Brink Mann (Germany) 2540MZ	01	
40	Microbial incubator	Hach (USA) 45900	01	
41	Microbial laminar	Viet Nam	01	
42	Portable incubator	Hach (USA)	01	
43	BOD incubator	HACH (USA) 205-	01	
44	BOD incubator	HACH (USA) 205	01	
45	Incubator	Shellab 1535	01	
46	Cooling cabinet	Sanyo (Japan) MIR-153	01	4^0C
47	Refrigerator	Sanaky (Japan) VH-260 HYW	01	
48	Refrigerator	Nationa (Japan) NR-C25V3H	01	
49	Deep freezer	Sanyo (Japan) MDF-235	01	
50	Fume hood	Viet Nam	01	
51	Fume hood	Labcaire (ENGLAND) 2450	01	

CHAPTER 3 ESSENTIAL INFORMATION FOR MONITORING PLAN DEVELOPMENT

3.1 River network in Re river basin

Re river is entirely situated in An Duong district, Hai Phong city, receiving water or being directly affected by surrounding big rivers such as Kinh Mon, Cam, Rang, Van Uc, and Lach Tray rivers (Fig. 3.1 & Fig. 3.2). Kinh Mon river originates from Kinh Thay river and runs along the boundary of Kinh Mon and Kim Thanh districts of Hai Duong province and then joins Han river at Nong confluence, forming Cam river. Cam river joins Bach Dang river when it is close to the coastal estuary. Rang river originates from Kinh Mon river and runs along the boundary of Kim Thanh and Thanh Ha districts of Hai Duong province; the river joins Gua river at the Cua Dua confluence, creating Van Uc river. Van Uc river runs a short distance from Cua Dua confluence before it is separated into one branch - Lach Tray river; the main flow of Van Uc river flows into the sea at Van Uc river mouth. Lach Tray river flows as a boundary between Kim Thanh district (Hai Duong province) and An Lao district (Hai Phong city) and then between An Lao and An Duong districts. After that, the river runs through Hai Phong city before it runs into the sea at Lach Tray river mouth. At the end of An Duong district, Lach Tray river is branched into a small flow which receives water from Re river and then separated into Tam Bac and Thuong Ly rivers, linking to Cam river. The beginning of Re river is named as Dau river; Dau river gets water from Rang river through Quang Dat and Bang Lai rivers; additionally, it also receives water from Kinh Mon river through Kim Son gate. Bang Lai and Ha Nhuan rivers merge at the confluence, the starting point of Dau river. Ha Nhuan river connects with Lach Tray river through Ba Muu river. Dau river runs through An Duong district; when it reaches Re bridge over National Highway No 10, it is called Re river. Re river – from Re bridge to the confluence with Lach Tray river – is over 10 km in length. Irrigation canal systems receiving water from Re river include a canal system called An Kim Hai on the left side of the river and a canal system named Bac Nam Hung on the right side of the river. Important rivers and canals being located in Re river basin and having impacts on Re river are listed in table 3.1 and shown in figures 3.1 and 3.2.

Table 3.1: List of major rivers and canals in Re river basin

Rivers/streams	**Length (km)**	**Dam/gate**	**Characteristics**
Rang/Lai Vu/Tuong Vu rivers	26	*Not determined*	*No information*
Van Uc river	45		
Lach Tray river	49		
Kinh Mon river	39		
Cam river	26		
Bach Dang river	27		
Tam Bac river	3		
Thuong Ly river	2		
Quang Dat river	8	Quang Dat gate	Water supply for Re river from Rang river
Bang Lai/Van Duong/Co Bong river	21	Bang Lai gate	
Kim Son canal	3	Kim Son gate	Water supply for Re river from Kinh Mon river
Ha Nhuan river	11	CT3 gate	Flow direction depends on the

Rivers/streams	Length (km)	Dam/gate	Characteristics
Ba Muu river	4	Tinh Thuy gate	opening/closing of gates
Dau/Ha Lien river	9		River last from Cu hamlet, Le Thien commune to Re bridge (National highway 10), Bac Son commune
Re river	12	Sen & Cai Tat gate	River last from Re bridge (National highway 10), Bac Son commune to Trai Chuoi ward, Hong Bang district
An Kim Hai canal	*No information*	Sen, Nhu Kieu, & Tien Sa gate	Receiving water from Lach Tray river and Re river
Bac Nam Hung canal		Tay Ha & An Tri gate	Receiving water from Re river through Tay Ha gate and discharging into Re river through An Tri gate
Song Mai canal		Vật Cách DWTP gate	Flowing into Cam river

Tidal area does not have direct effects on Re river, yet possibly indirectly affecting it. Salt intrusion influences water quality of Lach Tray river, Cam river, Van Uc river and possibly Rang river and Kinh Mon river. Meanwhile, Re river receives water from Rang river, Kinh Mon river, Lach Tray river, and in the future possibly from Cam river through gates, pumping stations at water intake points. Though gates and pumping stations are only open for water intake when big water supply rivers are not intruded by salt, salt intrusion affects the opening or closing of gates and pumping stations and therefore, may have influences on water supply for Re river when necessary.

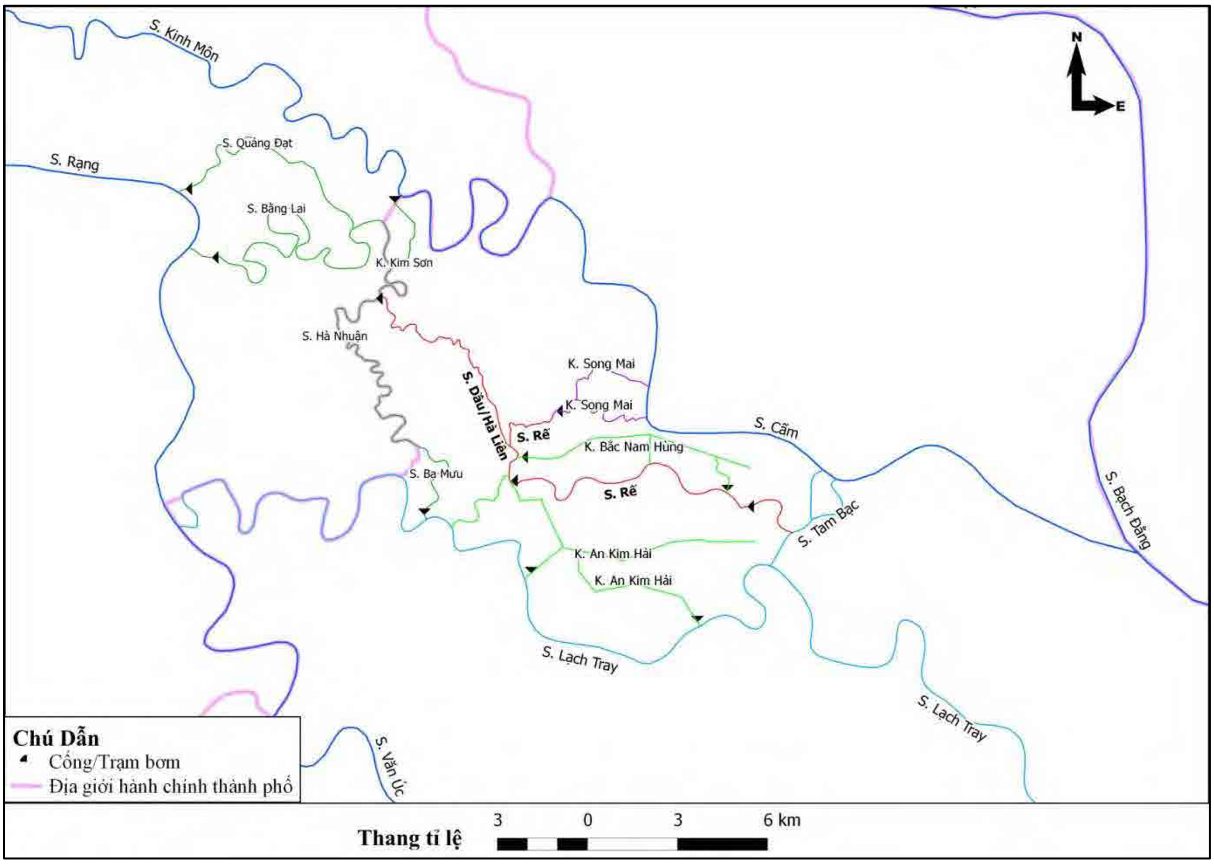


Fig. 3.1: River and canal system structure in Re river basin in Hai Phong city

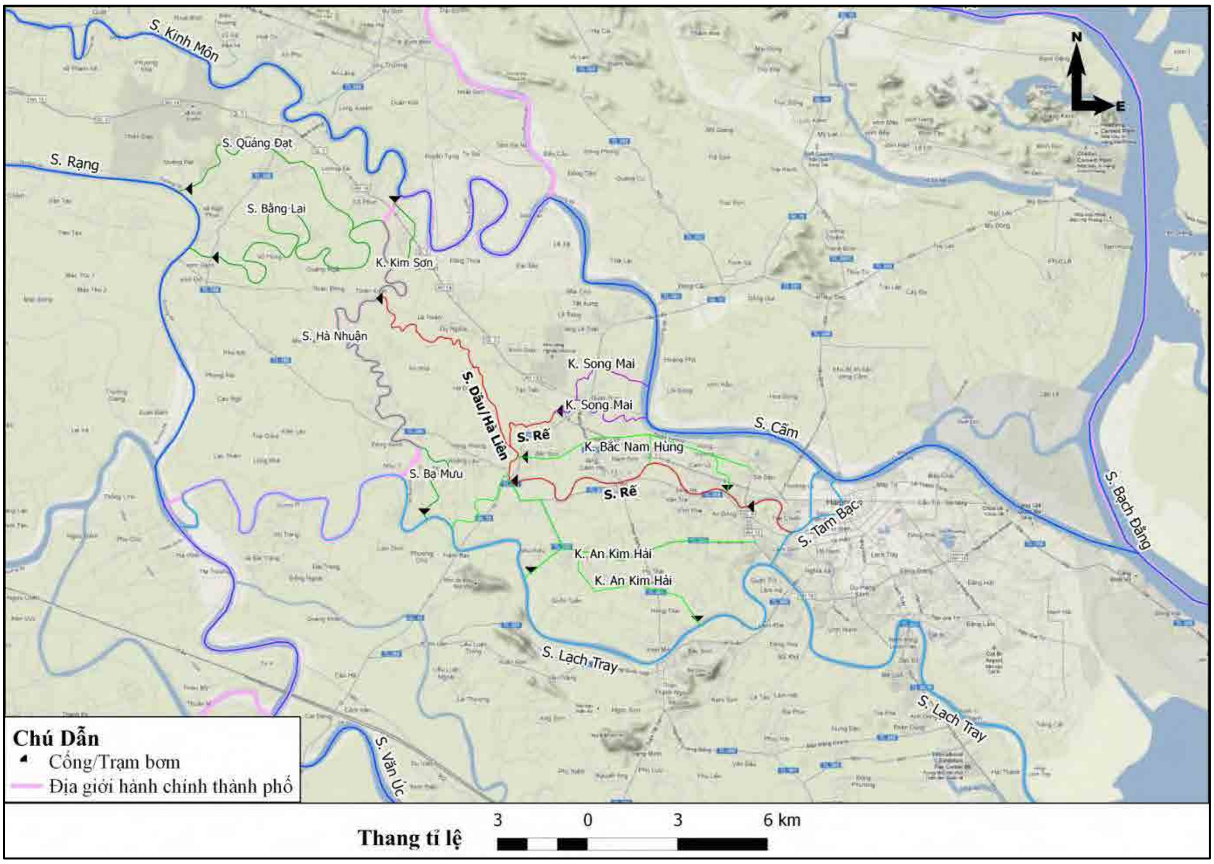


Fig. 3.2: River and canal system in Re river basin of Hai Phong city on topographic map

<u>Operation of gates in An Kim Hai irrigation system</u>

Re river is essentially a closed water body. Re river water level is controlled by the opening or closing of inlet and outlet gates (Fig. 3.3). Re river may receive water from three sources including Bang Lai river, Ha Nhuan river and Kim Son canal. Re river mainly receives water from Rang river through Bang Lai river which is regulated by Bang Lai and Quang Dat gates in Kim Thanh district, Hai Duong province. Re river gets a limited amount of water from Kinh Mon river through Kim Son canal, being regulated by Kim Son gate and from Ha Nhuan river or further from Ba Muu river and Lach Tray river, being regulated by CT3 and Tinh Thuy gates. Besides, An Kim Hai canal system receives water from both Re and Lach Tray rivers. Water from Lach Tray river flows into An Kim Hai canal system through Nhu Kieu and Tien Sa gates. When water level in An Kim Hai canal system is higher than in Re river, Re river will receive a part of water from this canal system. If water level of Re river is higher than that of An Kim Hai canal system, water from Re river will be adjusted to flow into this canal system through gates and pumping stations, such as Sen gate. Water of Re river can also supplies for Bac Nam Hung canal system through Tay Ha gate; this canal system water flows into Re river through An Tri gate at the end section of Re river. One branch of Re river supplies water for Vat Cach water factory. Reservoirs in Vat Cach water factory is separated from Song Mai canal system by Vat Cach DWTP gate. Thus, water from Song Mai canal runs into Cam river other than flowing into the reservoirs of the DWTP. Only when Re river water level is higher than Song Mai canal water level is this separation gate opened. Sen gate divides Re river at Re bridge (on National Highway 10 over Re river) to regulate water level on Re river where water can be used for domestic water factories and irrigation canal systems. Cai Tat gate is the last one of Re river which helps prevent salt intrusion into Re river. Cai Tat gate is only open during high water level of Re river and low seawater level. Opening or closing of Cai Tat and An Tri gates is harmoniously conducted to prevent pollution of upstream Quan Vinh pumping station area (Fig. 3.7) caused by Bac Nam Hung canal water. When An Tri gate opens, Cai Tat gate needs opening as well so that water from Bac Nam Hung canal runs directly into Lach Tray river. In some cases, when water level on Re river is higher compared with Bac Nam Hung canal, An Tri gate can be opened to receive water from Re river for irrigation and canal cleaning purposes.

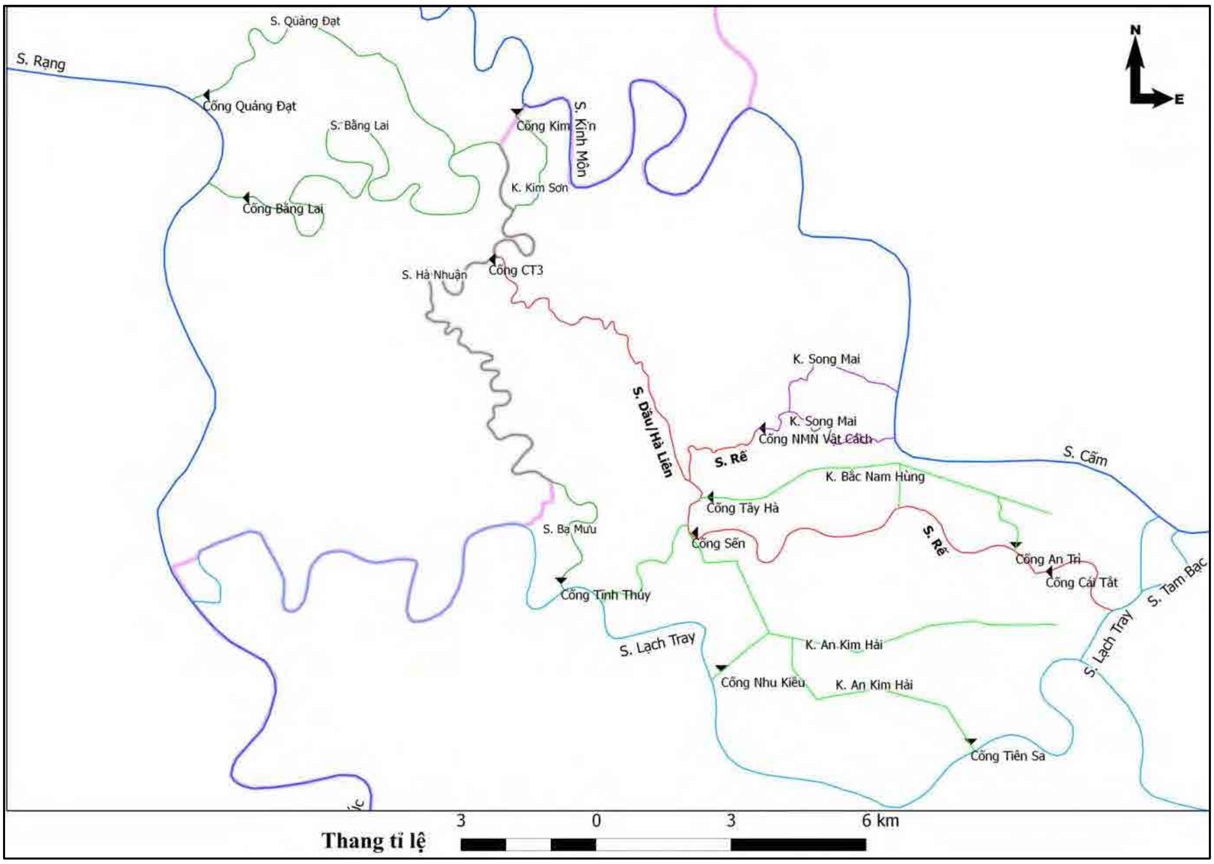


Fig. 3.3: Location of important irrigation gates in Re river basin.

3.2 Land use categories

(1) Land use classification

According to Resolution No 36/2006/NQ-CP dated 28th December 2006 on revised land use planning till 2010 and five-year land use plan (2006-2010) of Hai Phong city, land use status of Hai Phong city is presented in the table below.

Table 3.2: Land use planning for Hai Phong city till 2010.

No	Land type	Area (ha)	Percentage (%)
	TOTAL NATURAL AREA	151,938	100.00
1	AGRICULTURAL LAND	84,963	55.92
1.1	Agricultural land	49,759	
1.1.1	Annual crop land	45,666	
1.1.1.1	Rice cultivation land	44,883	
1.1.1.2	Remaining annual crop land	783	
1.1.2	Perennial crop land	4,092	
1.2	Forestry land	21,613	
1.2.1	Production forest land	459	
1.2.2	Protection forest land	12,833	
1.2.3	Special use forest land	8,322	
1.3	Aquaculture land	13,135	
1.4	Salt making land	156	
1.5	Other agricultural land	300	
2	NON-AGRICULTURAL LAND	63,125	41.55
2.1	Residential land	12,659	
2.1.1	Rural residential land	9,577	
2.1.2	Urban residential land	3,082	
2.2	Special use land	23,927	
2.2.1	Land for govermental office& public service	369	
2.2.2	Land for national defence & security	1,923	
2.2.2.1	National defence land	1,778	
2.2.2.2	Security land	145	
2.2.3	Non-agricultural production and bussiness land	5,487	
2.2.4	Land for public purposes	16,148	
2.2.4.1	Transportation land	7,523	
2.2.4.2	Land for irrigation structure	6,750	
2.2.4.3	Land for energy and communication transfer	82	
2.2.4.4	Cultural works land	269	
2.2.4.5	Land for health care/medical sector	123	
2.2.4.6	Land for education & training	717	
2.2.4.7	Land for sport sector	260	
2.2.4.8	Market land	59	
2.2.4.9	Historical, cultural relics land	179	
2.2.4.10	Land for waste disposal & treatment	184	
2.3	Land for religous beliefs	279	
2.4	Cemetery land	1,132	
2.5	Rivers, streams and specially used water surface	25,121	
2.6	Other non-agricultural land	7	
3	**UNUSED LAND**	3,850	2.53
3.1	Unused surface land	2,528	
3.2	Unused hilly and mountainous land	374	
3.3	Rocky mounts without forest tree coverage	948	

(2) Land use maps

The following figures from figure 3.4 to figure 3.6 show land use status in Hai Phong city in

2010, focusing on An Duong district and Hong Bang district. The maps are developed by Technical Centre for Natural Resources & Environment – Hai Phong DONRE.

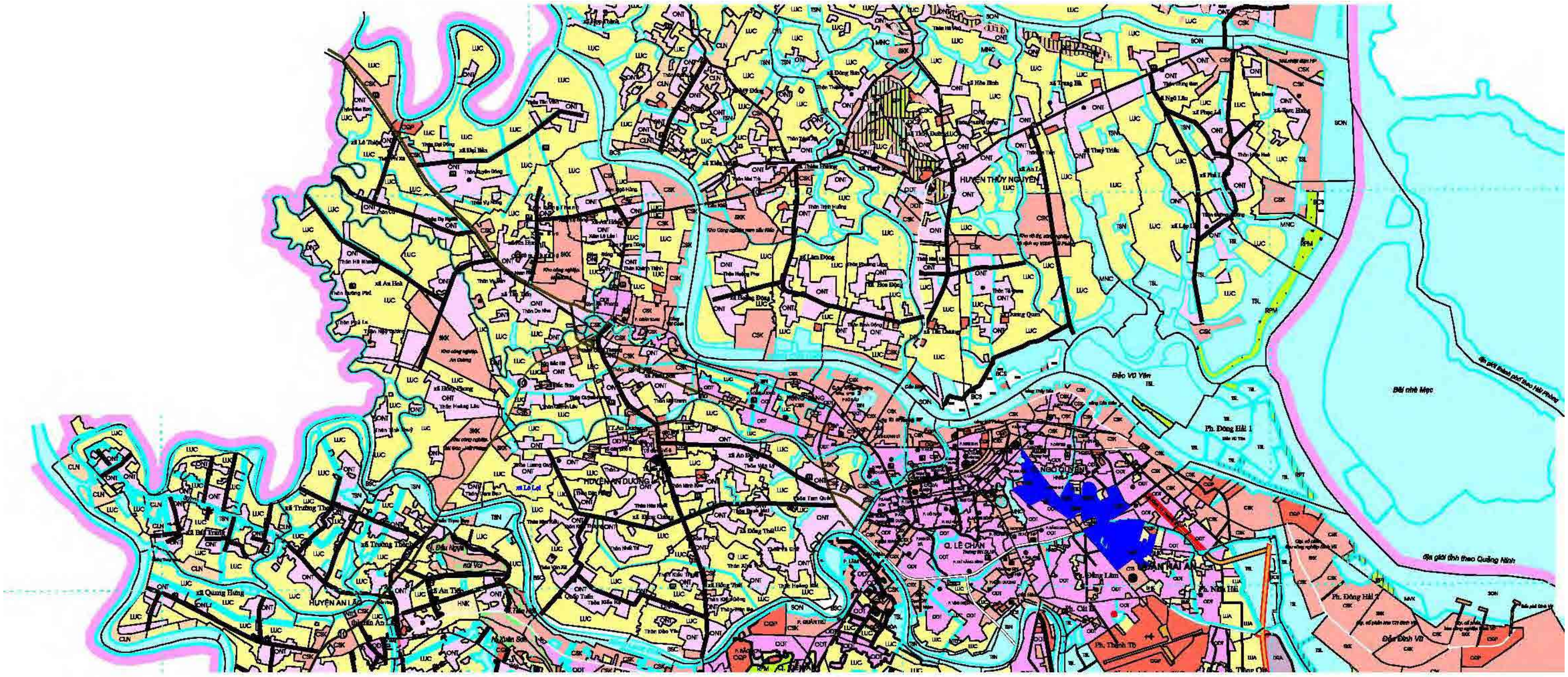
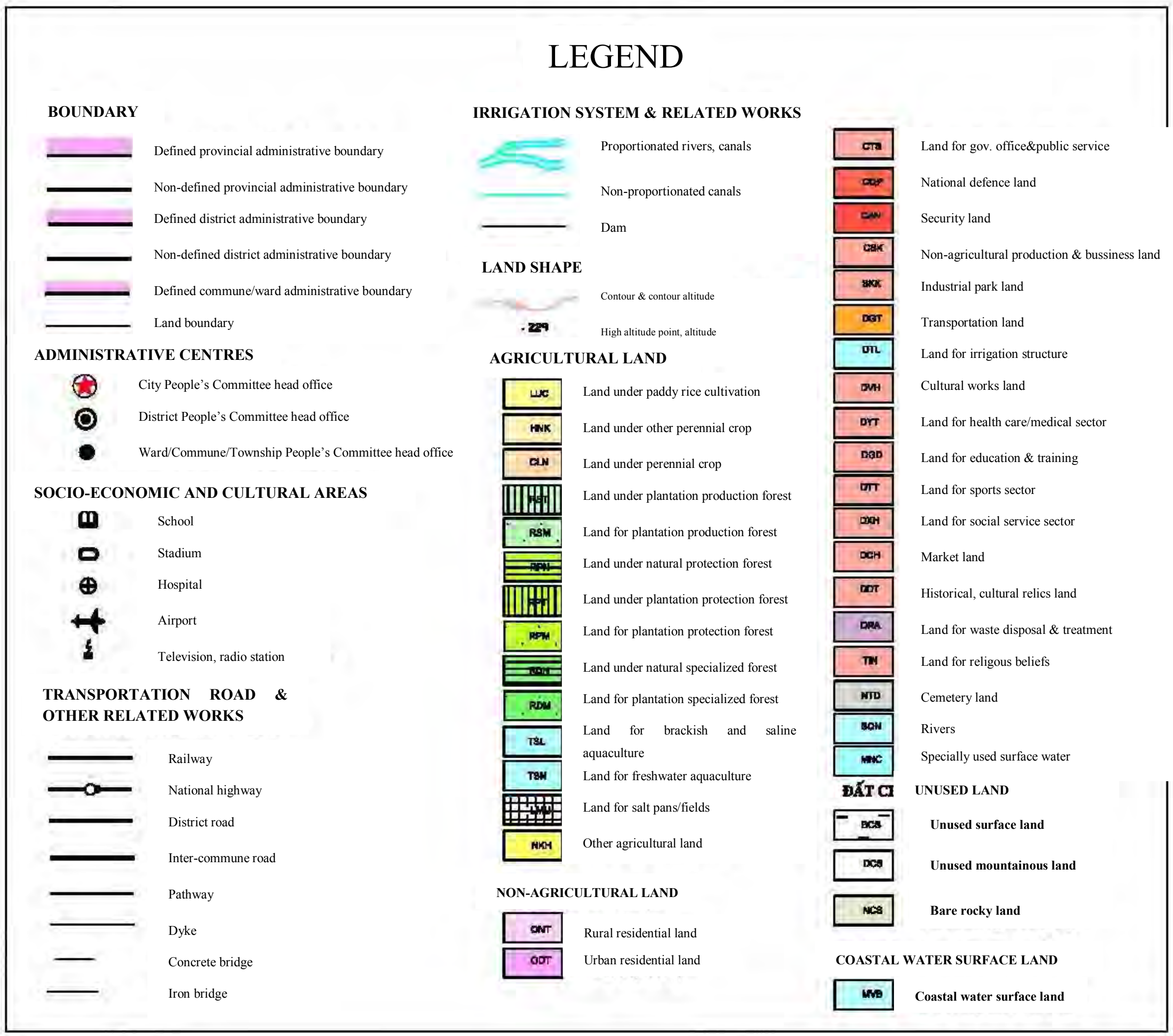


Fig. 3.4: Map of land use status in 2010 in districts of Hai Phong city in Re river basin


LEGEND
BOUNDARY
Defined provincial administrative boundary
Non-defined provincial administrative boundary
Defined district administrative boundary
Non-defined district administrative boundary
Defined commune/ward administrative boundary
Land boundary
ADMINISTRATIVE CENTRES
City People's Committee head office
District People's Committee head office
Ward/Commune/Township People's Committee head office
SOCIO-ECONOMIC AND CULTURAL AREAS
School
Stadium
Hospital
Airport
Television, radio station
TRANSPORTATION ROAD & OTHER RELATED WORKS
Railway
National highway
District road
Inter-commune road
Pathway
Dyke
Concrete bridge
Iron bridge
IRRIGATION SYSTEM & RELATED WORKS
Proportionated rivers, canals
Non-proportionated canals
Dam
LAND SHAPE
Contour & contour altitude
·229
High altitude point, altitude
AGRICULTURAL LAND
LUC
Land under paddy rice cultivation
HNK
Land under other perennial crop
CLN
Land under perennial crop
Land under plantation production forest
RSM
Land for plantation production forest
Land under natural protection forest
Land under plantation protection forest
RPM
Land for plantation protection forest
Land under natural specialized forest
RDM
Land for plantation specialized forest
TSL
Land for brackish and saline aquaculture
TSN
Land for freshwater aquaculture
Land for salt pans/fields
NKH
Other agricultural land
NON-AGRICULTURAL LAND
ONT
Rural residential land
ODT
Urban residential land
CTS
Land for gov. office&public service
CQP
National defence land
CAN
Security land
CSK
Non-agricultural production & bussiness land
SKK
Industrial park land
DGT
Transportation land
DTL
Land for irrigation structure
DVH
Cultural works land
DYT
Land for health care/medical sector
DGD
Land for education & training
DTT
Land for sports sector
DXH
Land for social service sector
DCH
Market land
DDT
Historical, cultural relics land
DRA
Land for waste disposal & treatment
TIN
Land for religous beliefs
NTD
Cemetery land
SON
Rivers
MNC
Specially used surface water
ĐẤT CI
UNUSED LAND
BCS
Unused surface land
DCS
Unused mountainous land
NCS
Bare rocky land
COASTAL WATER SURFACE LAND
MVB
Coastal water surface land

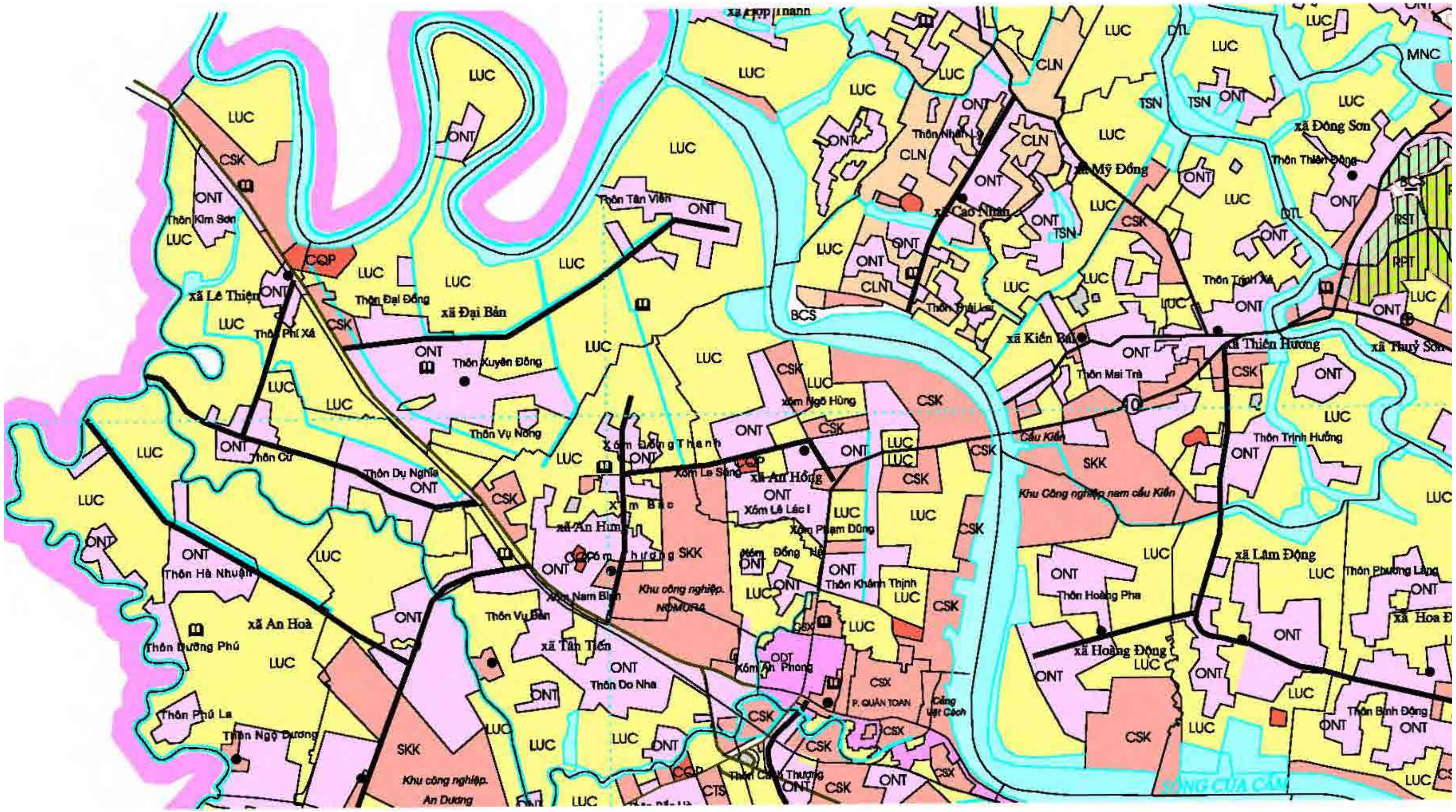


Fig. 3.5: Map of land use status in 2010 in Hai Phong city in upstream Re river area