

Fig. 3.6: Land use status of 2010 in Hai Phong city in downstream Re river area

3.3 Location of intake points

3.3.1 Intake points for domestic water factories

Intake points from Re river providing water for domestic water factories are shown in table 3.3 and figure 3.7.

Table 3.3: List of intake points from Re river for domestic water factories

No	Intake points	Location	Source	Domestic water supply factories	Total exploited water in 2012 (m ³)
1	An Hoa	An Hoa commune, An Duong district	Re river	An Hoa DWTP (4 plants)	20,400
2	Du Nghia	Du Nghia hamlet, Le Thien commune, An Duong district		Du Nghia DWTP	15,000
3	Ho Guom	An Hung commune, An Duong district		Ho Guom garment company	84,000
4	Tan Tien	Tan Tien commune, An Duong district		Tan Tien DWTP	43,200
5	Vat Cach	Do Nha hamlet, Tan Tien commune, An Duong district		Vat Cach DWTP (11,000 m ³ /day)	3,487,000
6	Nam Son	Nam Son commune, An Duong district		Nam Son DWTP (500 m ³ /day)	15,000
7	Quan Vinh	Vinh Khe hamlet, An Dong commune, An Duong district		An Duong DWTP (100,000 m ³ /day)	42,790,000

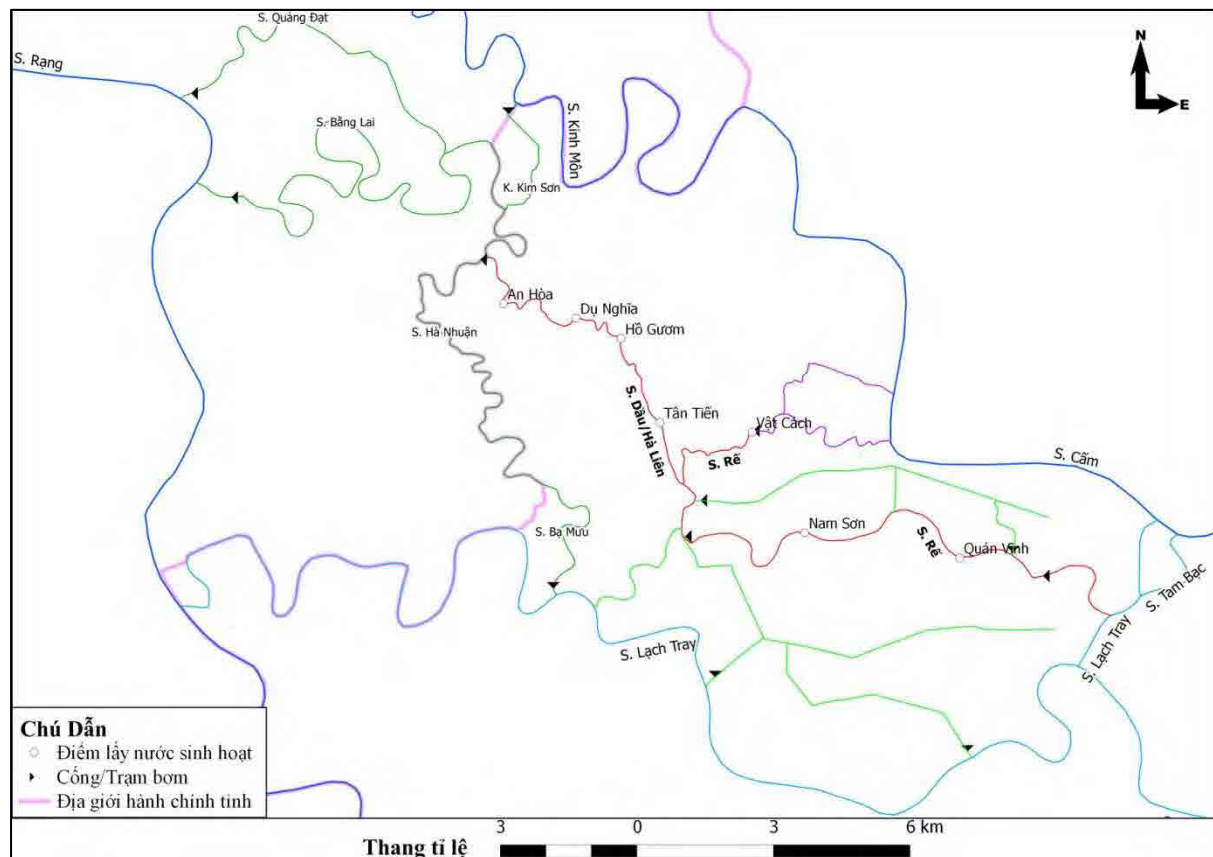


Fig. 3.7: Location of Re river water intake points for domestic water factories

3.3.2 Intake points for agricultural activities

According to the information from An Hai Irrigation Works Management Company, water intake points comprising gates and pumping stations to collect water from Re river for agricultural production are distributed along the river. Therefore, in this monitoring plan, even distribution of intake points along Re river and protection of the river for agricultural production are taken into consideration other than intake points' own location. Some general information on agricultural irrigation area with water supply from An Kim Hai system and pump stations of An Kim Hai system can be found respectively in table 3.4 and table P-1 in Appendices.

Table 3.4: Agricultural irrigation area with water supply from An Kim Hai system

No	Irrigation method	Area (ha)		
		Spring crop	Summer crop	Annual Total
1	Electric pump	2,243.05	1,856.43	4,099.48
2	Natural flow	205.28	703.46	908.74
3	Source supply	411.34	401.60	812.94
4	Source creation	1,191.82	1,047.31	2,239.13
5	Subsidiary crop	945.18	794.28	1,739.46
6	Aquaculture	107.79	106.09	213.88
Total		5,104.46	4,909.27	10,013.73

3.4 Location of pollution sources

Potential pollution sources in two districts of An Duong and Hong Bang are listed in table 3.5 below. This list is mainly obtained from the results of PSI activities along Re river under SCOWEM project (JICA, 2012) & satellite images.

Table 3.5: List of potential pollution sources in Re river basin

No	Enterprises	Address	Coordinates (WGS-84/UTM)		Production categories	Main pollutants	Wastewater (m ³ /day) & treatment measures (if any)	Possible receiving sources
			X	Y				
1	Hoang Gia shipbuilding company	Le Thien commune, An Duong district	2316894	660490	Shipbuilding	SS, mineral oil& grease, phenol		Kim Son canal
2	Kansai Thang Long steel joint stock company	Km 18, QL 5, Le Thien commune, An Duong district	2315823	661249	Steel production	Heavy metal, As	110 m ³ /day; production water is recycled	Kim Son canal
3	Hong Ha shipbuilding one-member Ltd. Company	Le Thien commune, An Duong district	2315168	661718	New shipbuilding and repairing	SS, mineral oil& grease, phenol		Kinh Mon river
4	HAPACO joint stock company - HPP	Dai Ban commune, An Duong district	2314749	662027	Packaging paper production	SS, BOD, COD, color, organic halogen	113 m ³ /day; treatment: Indian technology	Kinh Mon river
5	LG electronics in Hai Phong	Dai Ban commune, An Duong district	2314531	662220	Production of electrical appliances	Heavy metal, As, mineral oil& grease		Kinh Mon river
6	Ben Kien shipbuilding factory	An Hong commune, An Duong district	2314059	667421	Shipbuilding	Mineral oil& grease, phenol		Cam river

No	Enterprises	Address	Coordinates (WGS-84/UTM)		Production categories	Main pollutants	Wastewater (m ³ /day) & treatment measures (if any)	Possible receiving sources
			X	Y				
7	Van Loi steel joint stock company	An Hong commune, An Duong district	2311970	667835	Steel making	Heavy metal, As		Song Mai canal
8	Long Son joint stock company	Song Mai hamlet, An Hong commune, An Duong district	2311648	667716	Shoe production			Song Mai canal
9	Tan Long-Contrexim casting joint stock company	An Hong commune, An Duong district	2311573	667929	Casting products	Heavy metal, As, mineral oil & grease, CN ⁻		Song Mai canal
10	Cuu Long heavy industry joint stock company	Quan Toan ward, Hong Bang district	2311256	667480	Steel billet production	Heavy metal, As	Production water (182 m ³ /day) is recycled	Song Mai canal
11	VSC-Posco steel limited company	Quan Toan ward, Hong Bang district	2310899	667865	Steel production	Heavy metal, As	Production water is partially recycled and partially treated.	Song Mai canal
12	Vietnam-Japan Steel Joint Stock Company	Quan Toan ward, Hong Bang district	2310600	667353	Construction steel & steel billet production	Heavy metal, As	Production water is recycled	Song Mai canal
13	VINAUSTEEL company	Quan Toan ward, Hong Bang district	2310590	667537	Steel production	Heavy metal, As	Production water is recycled	Song Mai canal
14	Australian SSE steel production company	Quan Toan ward, Hong Bang district	2310607	667646	Steel production	Heavy metal, As	Production water is recycled (160 m ³ /day)	Song Mai canal
15	Viet Nam steel pipe limited company (VINAPIPE)	Quan Toan ward, Hong Bang district	2310587	667787	Black steel pipe & zinc-plated pipe production	Heavy metal, As	86 m ³ /day	Song Mai canal
16	Xuan Hoa steel joint stock company	Quan Toan ward, Hong Bang district	2310427	667506	Steel products	Heavy metal, As		Song Mai canal
17	Tan Huong investment & trading joint stock company	No 171, Hung Vuong road, Quan Toan ward, Hong Bang district	2310249	668353	Steel billet production	Heavy metal, As	Cooling water is recycled	Cam river
18	Duyen Hai machinery one member state limited company	No 133, Hung Vuong road, Quan Toan ward, Hong Bang district	2310008	668301	Speed reducer, hydropower bow valve	Heavy metal, As, mineral oil & grease, CN ⁻	Cooling induction furnace: 5 m ³ /day	Cam river
19	Cuu Long Vinashin manufacturing & assembly joint stock company	Tay Ha, Bac Son commune, An Duong district	2309446	664855	Mechanical equipment manufacturing	Heavy metal, As, mineral oil & grease, CN ⁻		Re river
20	Ngoc Thuy temper glass limited company	Bac Ha, Bac Son commune, An Duong district	2309962	665835	Temper glass production	Cl ₂ , phenol, CN ⁻	0.5 m ³ /day	Re river
21	Dinh Tuan Construction Ltd. Company	Bac Ha, Bac Son commune, An Duong district	2309868	665872	Concrete sewer pipe production	Mineral oil & grease	1.5 m ³ /day	Re river
22	Thanh Nam Trading Joint Stock Company	No. 9, 351 road, Cach Thuong, Nam Son commune, An Duong district	2309740	666661	Agricultural stock pile	NH ₄ ⁺ , F ⁻ , phenol, mineral oil & grease, pesticides		Bac Nam Hung canal
23	Central Pharmaceutical Joint Stock	No 28, road 351, Cach Thuong, Nam Son commune, An	2309459	666760	Pharmaceutical products	Cl ₂ , phenol, CN ⁻	Biological treatment	Bac Nam Hung canal

No	Enterprises	Address	Coordinates (WGS-84/UTM)		Production categories	Main pollutants	Wastewater (m ³ /day) & treatment measures (if any)	Possible receiving sources
			X	Y				
	Company No 3	Duong district						
24	Hai Phong scale joint stock company	Cach Thuong, Nam Son commune, An Duong district	2309831	666823	Producing scales of different types	Heavy metal, As, mineral oil & grease, CN ⁻		Bac Nam Hung canal
25	Bach Dang plastic joint stock company	Km 87+800, National highway No 5, Nam Son commune, An Duong district	2309835	667038	Plastic products (uPVC & HDPE)	Cl ₂ , phenol, CN ⁻	Production water is recycled	Bac Nam Hung canal
26	Nam Vang joint stock company	Km 91, National highway 5, Nam Son commune, An Duong district	2309805	667103	Steel product production & processing	Heavy metal, As		Bac Nam Hung canal
27	Fertilizer & petroleum chemical joint stock company of Northern Viet Nam- Hai Phong storehouse	Km87, National highway No 5, Nam Son commune, An Duong district	2309761	667201	Fertilizer & chemical distribution storehouse	NH ₄ ⁺ , F ⁻ , phenol, mineral oil & grease, pesticide		Bac Nam Hung canal
28	Dung Hai Trading Limited Company	Km 95, National highway No 5, Nam Son commune, An Duong district	2309576	667502	Coiled steel processing	Heavy metal, As		Bac Nam Hung canal
29	Tan Thuan Phong limited company	Km 8, National highway No 5, Nam Son commune, An Duong district	2309624	667687	Hazardous waste treatment	SS, BOD, COD, heavy metal, As, NH ₄ ⁺ , coliform	25 m ³ /ngày; treatment method: neutralization, anaerobic digestion, activated sludge, floatation, oil separation, aeration, sedimentation, activated carbon absorption	Bac Nam Hung canal
30	Minh Thanh Industrial & Commercial Limited Company	Km8, National Highway No 5, Nam Son commune, An Duong district	2309490	667822	Steel production	Heavy metal, As		Bac Nam Hung canal
31	Hoang Huy Financial and Commercial Service & Investment Joint Stock Company	Km9, National Highway No 5, Nam Son commune, An Duong	2309442	667883	Production & assembly of automobiles and motorcycles	Heavy metal, As, mineral oil & grease	10 m ³ /day	Bac Nam Hung canal
32	Thai Don limited company	National Highway No 5, Nam Son commune, An Duong district	2309396	667908	Steel billet production	Heavy metal, As	Cooling water is recycled	Bac Nam Hung canal
33	Tam Chien Tachiko limited company	Km 9, National Highway No 5, Nam Son commune, An Duong district	2309413	668005	Production of electric wires of different types	Heavy metal, As, mineral oil & grease	Cooling water is recycled	Bac Nam Hung canal
34	Viet Nam-Shunlee Ltd. Company	Km88+900, National Highway No 5, Nam Son commune, An Duong district	2309381	668140	Production of molding press for plastic products,	Heavy metal, As, mineral oil & grease, CN ⁻		Bac Nam Hung canal

No	Enterprises	Address	Coordinates (WGS-84/UTM)		Production categories	Main pollutants	Wastewater (m ³ /day) & treatment measures (if any)	Possible receiving sources
			X	Y				
					toys			
35	Thu Minh joint stock company	Km89, National Highway No 5, Nam Son commune, An Duong district	2309499	668305	Production of porous insulation materials			Bac Nam Hung canal
36	Industrial development joint stock company -DIC	Km89, National Highway No 5, Nam Son commune, An Duong district	2309544	668323	Manufacturing of steel structure & mechanical products	Heavy metal, As, mineral oil & grease		Bac Nam Hung canal
37	Interior joint stock company No 190	Km89, National Highway No 5, Nam Son commune, An Duong district	2309510	668357	Steel pipe production, interior products	Heavy metal, As	60 m ³ /day; treatment: equalization tank/sand filtering tank /Anaerobic digestion tank/Aerobic digestion tank/Oil separator	Bac Nam Hung canal
38	Ha Quy limited company	Km 89, National Highway No 5, Nam Son commune, An Duong district	2309496	668422	Casting products, detailed processing	Heavy metal, As, mineral oil&grease, CN ⁻	Production water is recycled/reused	Bac Nam Hung canal
39	Hieu Huong limited company	Km 89, National Highway No 5, Nam Son commune, An Duong district	2309489	668437	Producing wood, wood products			Bac Nam Hung canal
40	An Nguyen casting limited company	Km 89, National Highway No 5, Nam Son commune, An Duong district	2309482	668455	Casting products, detailed processing	Heavy metal, As, mineral oil&grease, CN ⁻	Production water is recycled/reused	Bac Nam Hung canal
41	Hai Phong Messer industrial gas limited company	An Duong township, An Duong district	2308556	667392	Industrial gas production			Re river
42	Lam Binh Limited Company	Km 89, National Highway No 5, Hung Vuong ward, Hong Bang district	2309085	668765	Unfired brick production		30 m ³ /day	Bac Nam Hung canal
43	Hoang Phat ship industry joint stock company	Km 92, National Highway No 5, Hung Vuong ward, Hong Bang district	2308810	669744	Ship production, detailed processing	Heavy metal, As, mineral oil&grease, CN ⁻		Re river
44	Steel pipe limited company 190	Km 91, National Highway No 5, Hung Vuong ward, Hong Bang district	2308487	670603	Production & trading of steel products	Heavy metal, As	Production water is recycled	Bac Nam Hung canal
45	Vinh Khanh limited company (branch 1)	No 195B, National Highway No 5, Cam Lo, Hung Vuong ward, Hong Bang district	2308797	670554	Scented candle production			Bac Nam Hung canal
46	Branch of Viet Nam packaging joint stock company – Hung Vuong packaging enterprise	No. 525 Hung Vuong road, Hung Vuong ward, Hong Bang district	2309339	670728	Packaging production		Nước thải được xử lý	Bac Nam Hung canal
47	Binh An ship material & equipment production & ship building factory	National Highway No 5, Hung Vuong ward, Hong Bang district	2308261	671250	Ship equipment production	Heavy metal, As, mineral oil&grease, CN ⁻		Bac Nam Hung canal

No	Enterprises	Address	Coordinates (WGS-84/UTM)		Production categories	Main pollutants	Wastewater (m ³ /day) & treatment measures (if any)	Possible receiving sources
			X	Y				
48	Hoang Tan Joint Stock Company	Km 92+600, National highway No 5, Hung Vuong ward, Hong Bang district	2308229	671276	Plastic products	Cl ₂ , phenol, CN ⁻	Production water is recycled	Bac Nam Hung canal
49	Van Long Ltd. Company	Hung Vuong ward, Hong Bang district	2308687	671313	Plastic products	Cl ₂ , phenol, CN ⁻	Cooling water is recycled	Bac Nam Hung canal
50	Ky Anh Ltd. Company	Hung Vuong ward, Hong Bang district	2308846	671429	Bicycle rims and baskets	Heavy metal, As, mineral oil&grease	Cooling water is recycled	Bac Nam Hung canal
51	An Lac petroleum storehouse-Thuong Ly general petroleum store	An Lac, So Dau ward, Hong Bang district	2308974	671500	Petroleum storage	Mineral oil&grease		Bac Nam Hung canal
52	Technical material joint stock company VICADI	991A Ton Duc Thang, So Dau ward, Hong Bang district	2308380	671607	Insulation materials		10 m ³ /day	Bac Nam Hung canal
53	Chau Phuoc Thanh limited company	So Dau ward, Hong Bang district	2308656	671624	Plastic can	Cl ₂ , phenol, CN ⁻		Bac Nam Hung canal
54	Petroleum company of zone III	No 1, So Dau ward, Hong Bang district	2308921	672037	Petroleum trading	Mineral oil&grease		Cam river
55	Thuong Ly lubricant storehouse	So Dau ward, Hong Bang district	2309004	672334	Lubricant trading	Mineral oil&grease		Cam river
56	Chemical storehouse	So Dau ward, Hong Bang district	2309121	672475	Solvent trading	Phenol, mineral oil&grease		Cam river
57	Heavy Industry Ltd. Company of Doosan VINA HP	Km 92, National highway No 5, So Dau ward, Hong Bang district	2307833	671505	Steel products	Heavy metal, As	3.5 m ³ /day; treatment: neutralization tank, activated carbon absorption	Re river
58	Phu Duong Production&Trading Ltd. Company	Road 208, Vinh Khe, An Dong commune, An Duong district	2307433	671549	Printing & production of stamps & badges		1 m ³ /day	Re river
59	Viet Thang Foam Production&Trading Ltd. Company	Group 3, An Duong township, An Duong district	2307906	666500	Cushion	SS		Re river
60	An Duong hospital	An Duong township, An Duong district	2307978	667133	Hospital	SS, BOD, COD, NH ₄ ⁺ , NO ₃ ⁻ , PO ₄ ³⁻ , coliform, mineral oil&grease, sulphide		Re river
61	Mai Huong Ltd. company	Hong Thai commune, An Duong district	2305115	668790	Shoe production			An Kim Hai canal
Industrial parks								
No	Industrial park (IP)	Location	Area		Production category	Main pollutants	Wastewater (m ³ /day) and treatment measures	Possible wastewater receiving source
1	Nomura IP	An Hung commune,	153 ha, from 1994, entity coverage of				Wastewater treatment plant	Song Mai

No	Enterprises	Address	Coordinates (WGS-84/UTM)		Production categories	Main pollutants	Wastewater (m ³ /day) & treatment measures (if any)	Possible receiving sources
			X	Y				
		An Duong district	90%				10,800 m ³ /day	canal, Re river
2	An Duong IP	Hong Phong & Bac Son communes, An Duong district	200 ha, being under ground clearance and levelling				Wastewater treatment plant 13,000 m ³ /day; treated wastewater is discharged into Lach Tray river through irrigation canal of Hoang Lau hamlet, Hong Phong commune	Re river, Ba Muu, Lach Tray
3	Sai Gon – Hai Phong/Trang Due IP	Hong Phong & Le Loi communes, An Duong district	350 ha, from 2007, 16 investment enterprises				Wastewater treatment plant 7,000 m ³ /day (not yet been operated)	Re river, Lach Tray river

Pollution sources are confirmed to be released into Cam river, Kinh Mon, Song Mai canal (and then into Cam river), or An Kim Hai canal, mostly not affecting Re river water quality. Pollution sources of this type shall not be much considered during the development of Re river monitoring plan.

Pollution sources with wastewater discharge into Kim Son canal, Dau river and Re river should be taken into account. In addition, pollution sources discharging wastewater into Bac Nam Hung canal where water is released into Re river at My Chanh hamlet (Nam Son commune, An Duong district) need to be considered as well.

Pollution sources listed in table 3.5 can be seen in figure 3.8 and figure 3.9.

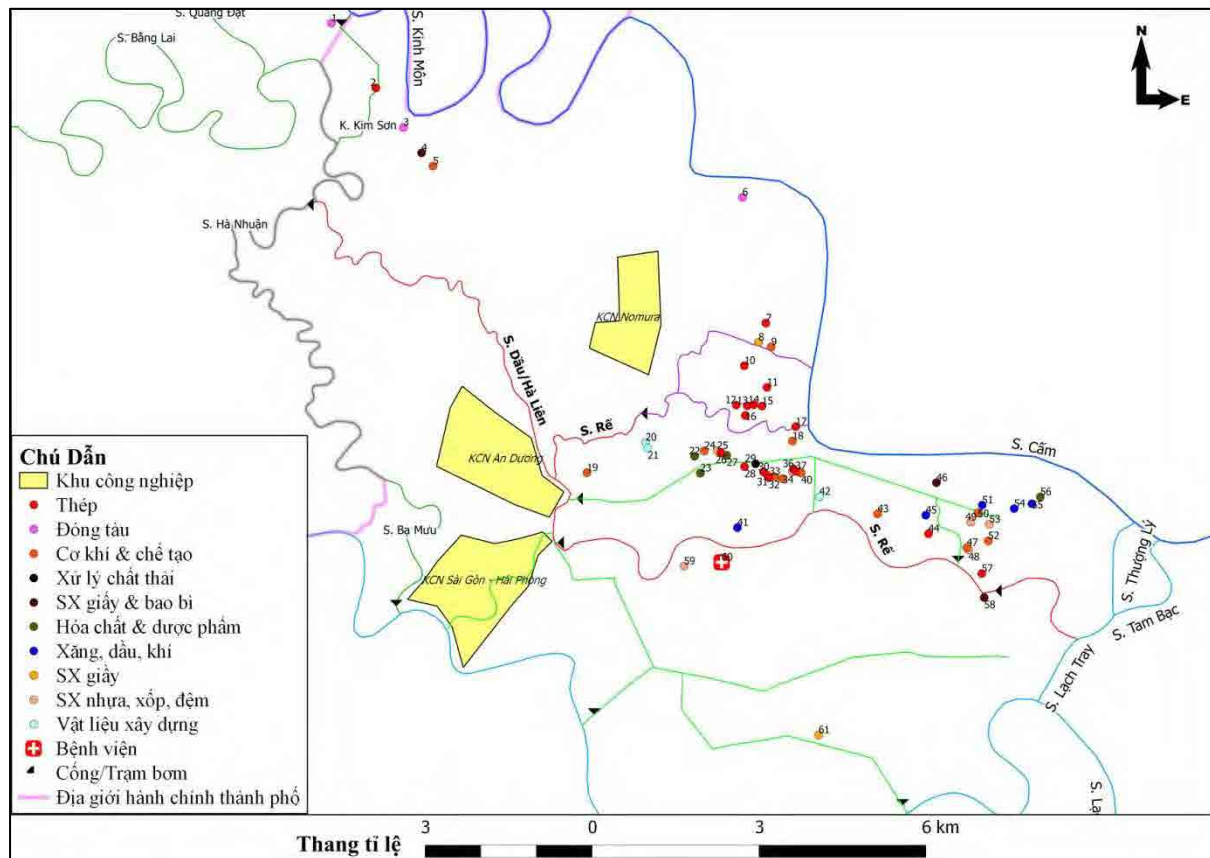


Fig. 3.8: Location of potential pollution sources in Re river basin

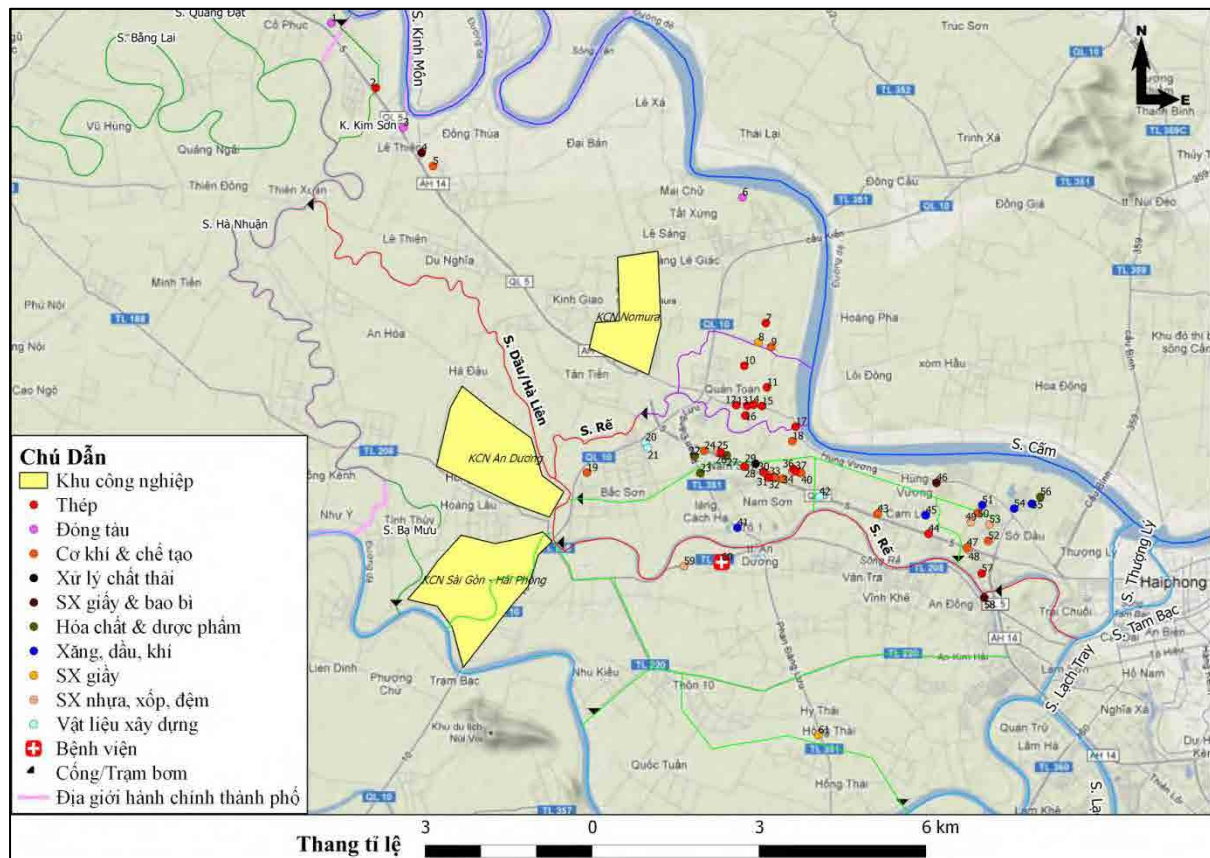


Fig. 3.9: Location of potential pollution sources in Re river basin on topographic map

3.5 Rainfall and other meteorological data

3.5.1 Location of meteorological stations

List of meteorological stations and independent rainfall stations in Hai Phong city is shown in table 3.6.

Table 3.6: List of meteorological stations in Hai Phong city

Station	Location	Coordinate		Monitoring data	
		Latitude	Longitude	Rainfall	Meteorological data
Phu Lien	Phu Lien, Kien An district	20 ⁰ 48'	106 ⁰ 38'	o	o
Bach Long Vi	Bach Long Vi island, Bach Long Vi district	20 ⁰ 08'	107 ⁰ 43'	o	o
Hon Dau	Hon Dau island, Do Son district	20 ⁰ 40'	106 ⁰ 48'	o	o
Cat Ba	Cat Ba township, Cat Hai district	20 ⁰ 43'	107 ⁰ 04'	o	o
Thuy Nguyen	Thuy Nguyen district	20 ⁰ 55'	106 ⁰ 41'	o	
Vinh Bao	Vinh Bao district	20 ⁰ 42'	106 ⁰ 27'	o	
Tan Phong	Kien Thuy district	No information		o	
An Lao	An Lao district			o	

Meteorological stations and independent rainfall stations can be seen in figure 3.10.

(3-20)

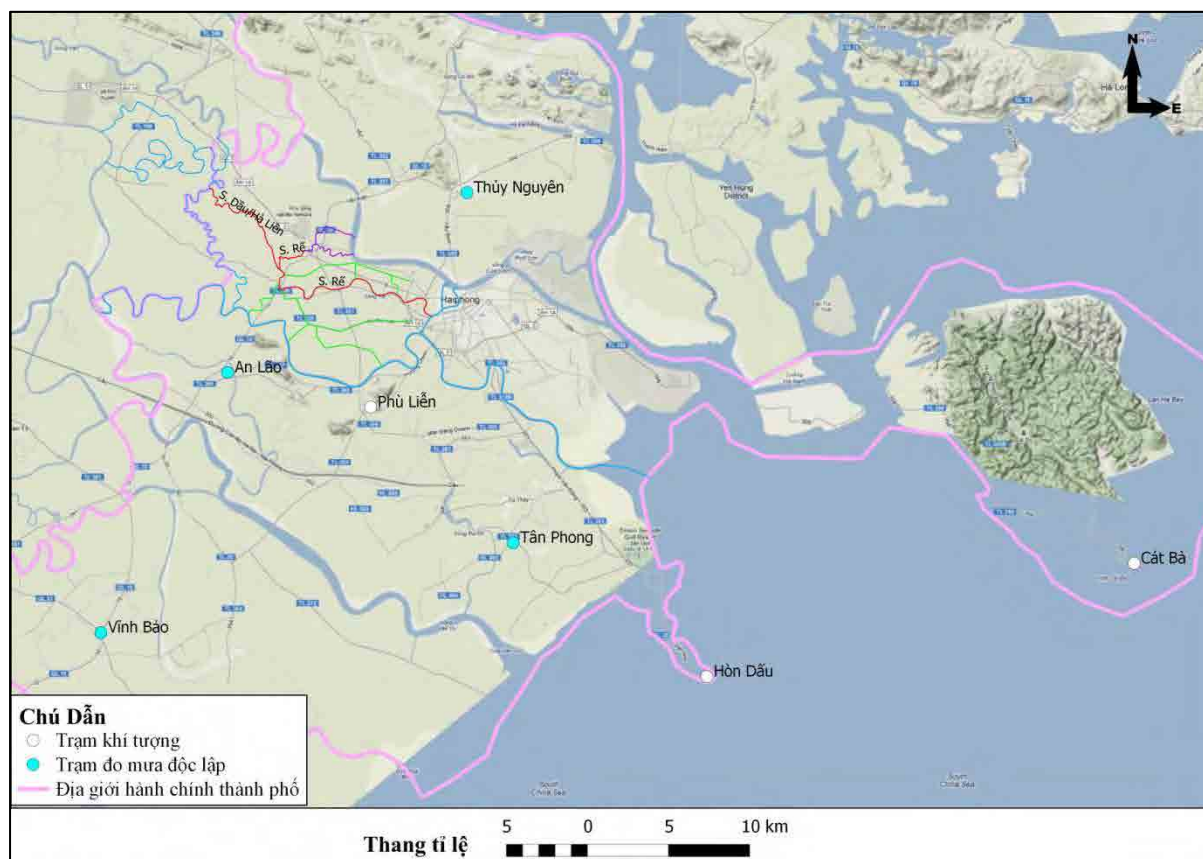


Fig. 3.10: Location of meteorological and rainfall stations in Hai Phong city.

3.5.2 Climatic conditions in Hai Phong City

The climate in Hai Phong city is characterized by that of Northern Viet Nam: being hot, humid with much rain and having 4 distinct seasons of spring, summer, autumn and winter. Dry and cold winter lasts from November to April with average temperature of 20.3°C; from May to October, it is a summer season, being humid, cool with much rain and average temperature of about 32.5°C. Due to its proximity to the sea, Hai Phong is 1°C warmer in winter and 1°C cooler in summer compared with Ha Noi. Average temperature of a year ranges from 23°C to 26°C; in the hottest month (June and July 7), the temperature amounts to as high as 44°C and the coldest month (January and February), the temperature reduces to as low as below 5°C. Average humidity is around 80 – 85%; the highest is found in July, August and September and the lowest in January and December. (Source: <http://haiphong.gov.vn/Portal/Detail.aspx?Organization=UBNDTP&MenuID=4518&ContentID=3161>).

Average rainfall varies from 1,600 – 1,800 mm/year. Specifically, average rainfall over years at Phu Lien station is illustrated in figure 3.11 below. High rainfall occurs mainly during summer months from May to October. The month with the highest rainfall is found in August, being approximately 350 mm on average. Rainfall during winter months (from November to April) is low. January sees the lowest rainfall, being below 30 mm on average.

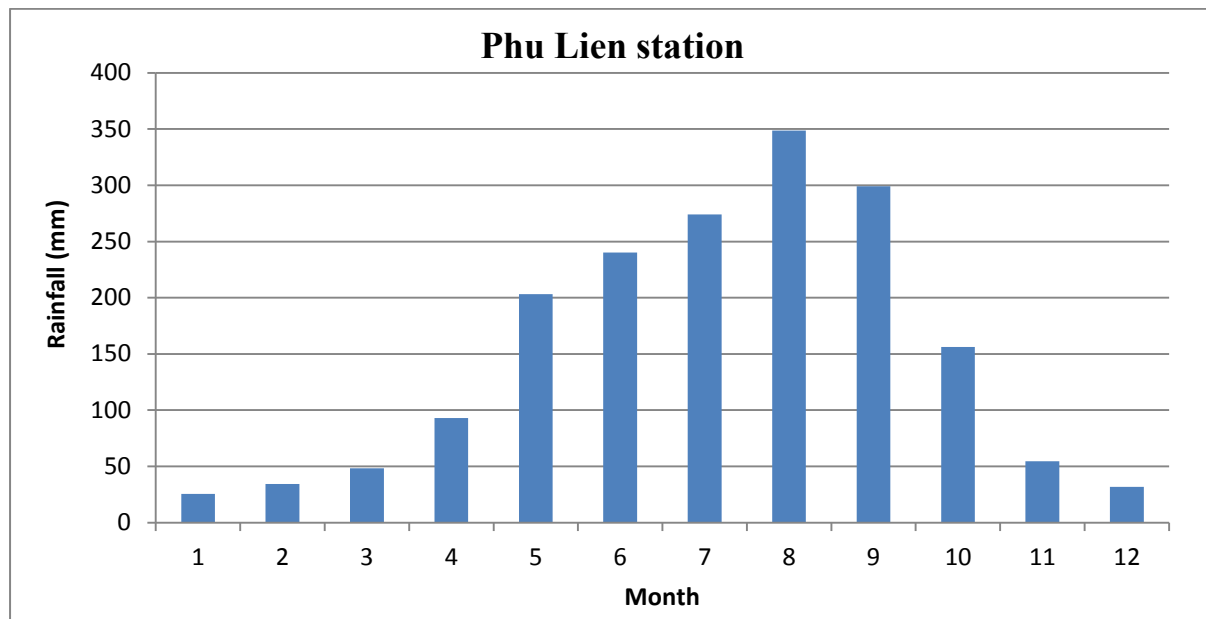


Fig. 3.11: Rainfall at Phu Lien station through years.

3.6 River flow discharge

3.6.1 Hydrological stations

Hydrological stations in Hai Phong city are listed in table 3.7 below.

Table 3.7: Hydrological stations in Hai Phong city

Stations	Location	River	Latitude	Longitude
Cua Cam	Hung Vuong ward, Hong Bang district	Kinh Thay	20°46'	106°50'
Trung Trang	Quang Hung commune, An Lao district	Van Uc	20°50'	106°30'
Tien Tien	Tien Tien commune, Tien Lang district	Moi	20°45'	106°31'
Do Nghi	Tam Hung commune, Thuy Nguyen district	Bach Dang	20°56'	106°46'
Dong Xuyen	Doan Lap commune, Tien Lang district	Thai Binh	20°41'	106°33'
Kien An	Bac Son ward, Kien An district	Lach Tray	20°49'	106°37'
Chanh Chu	Thang Thuy commune, Vinh Bao district	Luoc	20°44'	106°24'
Cao Kenh	Hop Thanh commune, Thuy Nguyen district	Kinh Thay	20°56'	106°35'
Quang Phuc	Quang Phuc commune, Tien Lang district	Van Uc	20°43'	106°36'
Cong Ro	Giang Bien commune, Vinh Bao district	Thai Binh	20°46'	106°31'

Location of hydrological stations is presented in figure 3.12.

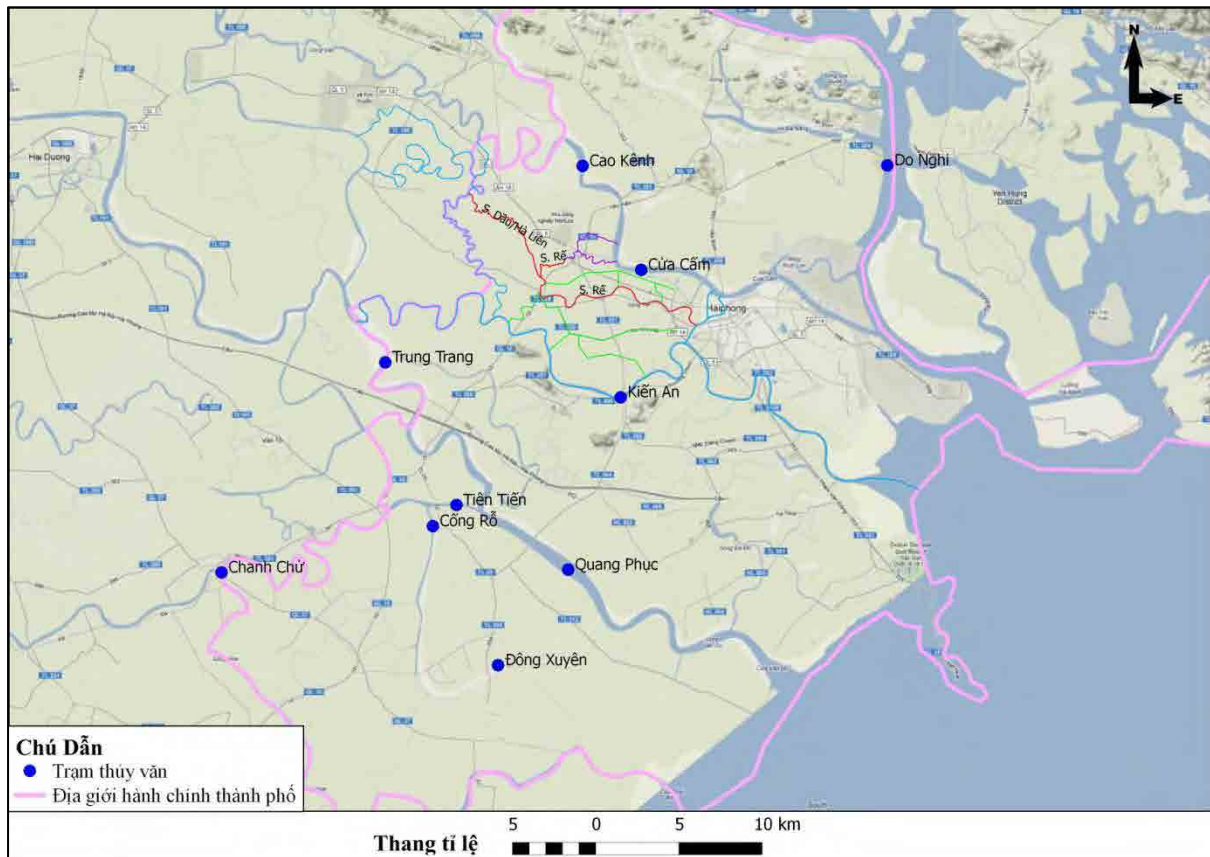


Fig. 3.12: Location of hydrological monitoring stations in Hai Phong city.

CHAPTER 4 MONITORING PLAN

4.1 Monitoring network

4.1.1 Principles for selection of monitoring points

Monitoring points are selected to:

- (i) Grasp water quality at water intake stations.
- (ii) Grasp water quality along the river from the starting point to final point (in terms of hydraulic structure or administrative boundary)
- (iii) Grasp river water quality in areas having high risk of pollution
- (iv) Be or be close to hydrological and meteorological monitoring points.

To meet the above requirements, monitoring points should be placed as follows:

- 1) At the starting and ending points of a river/stream in the province
- 2) At the area of water intake stations
- 3) Before and after the confluence with other rivers/streams which possibly have great impacts on water quality.
- 4) Before and after discharge points or a polluted area through which the river runs.
- 5) At the location representative of river water quality in an area having only non-point pollution sources.
- 6) Being close to known hydrological and meteorological monitoring points.

Based on these principles and characteristics of Re river system in Hai Phong province as presented above (characteristics of river system, location of dams, water intake stations, potential pollution sources, land use classification, hydrological stations ...), 8 monitoring points have been placed in Re river. Monitoring points are defined and described in figure 4.1 below. Specific location and coordinates of each monitoring point as well as detailed description and monitoring purpose of each monitoring point are shown in table 4.1.

4.1.2 Location of monitoring points

List of monitoring points in the monitoring plan for Re river water quality is presented in table 4.1.

Table 4.1: List of monitoring points in the monitoring plan for Re river water quality

No	Station code	Station name	Coordinates (WGS-84)		Location	Sampling location description	Purposes	Note
			Latitude	Longitude				
1	SR-1	Cu	20° 55.066'N	106° 32.559'E	Cu hamlet, Le Thien commune, An Duong district	In the middle of the river; 200m downstream of the confluence of Ha Nhuan and Bang Lai rivers; upstream of Re river	To check baseline data of river water quality	New point
2	SR-2	Phung Duong	20° 52.828'N	106° 34.637'E	Phung Duong area, Dinh Ngo hamlet, Hong Phong commune, An Duong district	In the middle of the river, 500 m upstream of the branching point where one branch of Re river runs toward Vat Cach DWTP	To check Re river water quality before the water is supplied to Vat Cach DWTP through Re river branch; to compare river water quality before and after the construction of An Duong Industrial Zone	Monitoring in 2011-2012
3	SR-3	Bac Ha	20° 53.013'N	106° 35.457'E	Bac Ha area, Bac Son commune, An Duong district	In the middle of the river, 400 m from Vat Cach water factory	To grasp influent water quality of Vat Cach water factory	Monitoring in 2011-2012
4	SR-4	Cong Sen	20° 52.018'N	106° 34.951'E	Trang Due hamlet, Le Loi commune, An Duong district	In the middle of the river, 300 m downstream of Sen gate; 100 m downstream of the junction of two Re river channels passing through Sen gate	To check impacts of An Duong and Trang Due Industrial Parks on Re river water quality; to control quality of water supplied for surrounding canals of Sen gate area	Monitoring in 2008-2011, (no monitoring in 2012)
5	SR-5	Luong Quy	20° 51.804'N	106° 35.849'E	Luong Quy hamlet, Le Loi commune, An Duong district	In the middle of the river, next to the provincial road 208, 200 m from Viet Thang cushion factory	To grasp river water quality in surrounding area	Monitoring in 2011-2012
6	SR-6	Cau Re	20° 52.018'N	106° 36.791'E	Group 3, An Duong township, An Duong district	In the middle of Re bridge, 600 m downstream of An Duong hospital	To grasp river water quality; to check impacts of discharge sources in An Duong township on river water quality	Monitoring in 2008-2012
7	SR-7	Quan Vinh	20° 51.819'N	106° 38.056'E	Van Tra hamlet, An Dong commune, An Duong district	In the middle of the river, Quan Vinh pumping station that supplies water for An	To grasp influent water quality of Quan Vinh pumping station	Monitoring in 2011-2012

*a**a**c*

No	Station code	Station name	Coordinates (WGS-84)		Location	Sampling location description	Purposes	Note
			Latitude	Longitude				
						Duong water factory		
8	SR-8	Cong Cai Tat	20° 51.598'N	106° 38.994'E	Cai Tat, An Dong, An Duong district	In the middle of the river, 50 m upstream of Cai Tat gate	To grasp water quality at the final point of Re river, to check impacts of discharge sources in surrounding areas on Re river water quality	Monitoring in 2008-2012

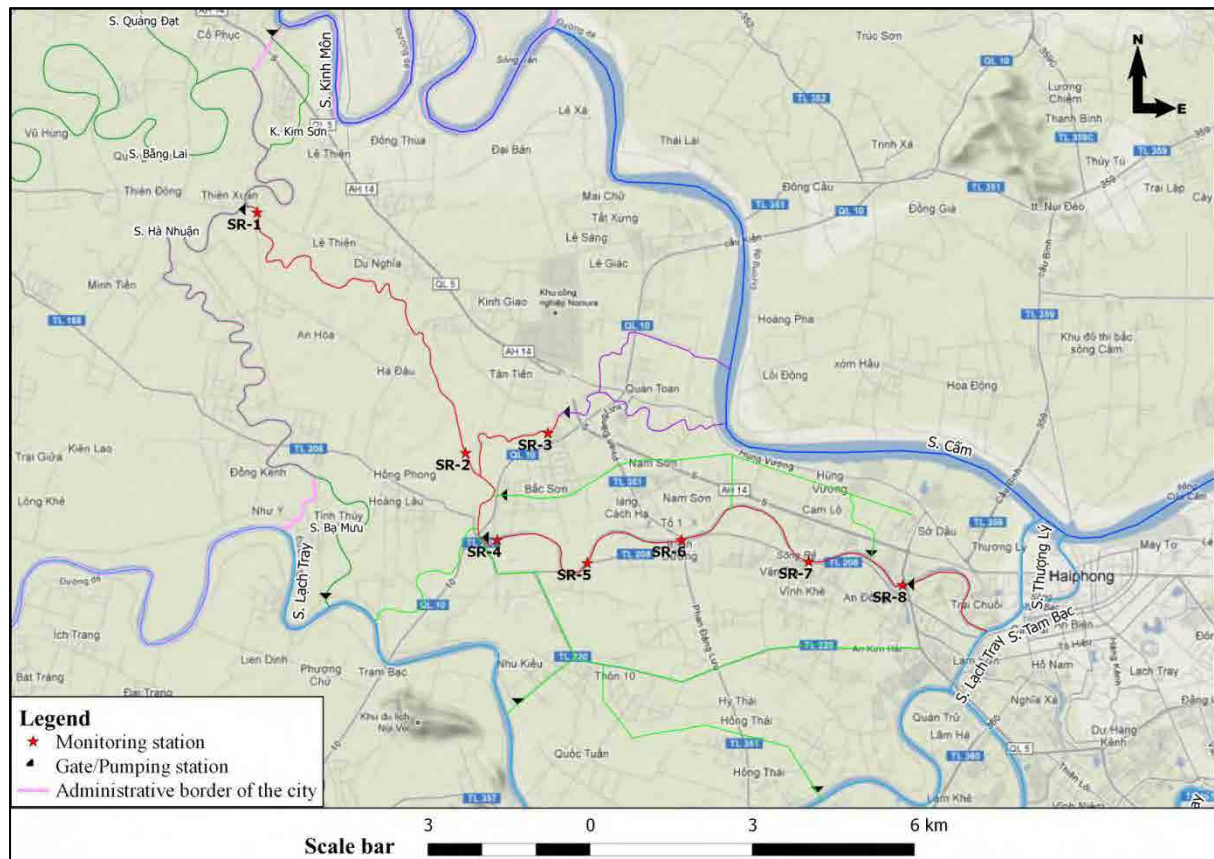


Fig. 4.1: Location of monitoring points of the monitoring plan for Re river water quality

Location of monitoring points in a connection with water intake points, and pollution sources can be shown in Appendices from P-1 to P-3.

4.2 Monitoring parameters

Parameters that need measuring along Re river to meet the requirements of water quality control are described in the table below.

Table 4.2: Water quality parameters that need measuring in Re river monitoring plan

No	Type	Parameter	Selection reasons	Analysis method	Analysis unit
1	Physical	Temperature	Circular 29, Decision 879, a basis for estimating saturate DO.	Field measurement	HACEM
2		Conductivity	Parameters accompanied to calculate salinity		
3		Salinity	To determine salt intrusion level		
4		pH	Circular 29, Decision 879, a basis for water quality and water properties		
5		DO	Circular 29, Decision 879, an important parameter for evaluating river health & impacts on organism life.		
6		Turbidity	Circular 29, Decision 879, basic		

No	Type	Parameter	Selection reasons	Analysis method	Analysis unit
7		TSS	parameter for determination of water quality & water properties.	Weight method	
8	Nutritional	COD	Decision 879, for assessing river water quality in general and impacts of domestic, agricultural and industrial wastewater	Dichromate oxidation and spectrometry measurements	
9		BOD ₅ (20 ⁰ C)		Method of dilution & culture with allylthiourea addition	
10		NH ₄ ⁺	Regulated by Decision 879 for assessing impacts of wastewater from daily/domestic activities, agricultural, seafood and agro-produce processing industries	spectrometry measurements	
11		NO ₃ ⁻	For assessing impacts of domestic wastewater and agricultural wastewater		
12		NO ₂ ⁻			
13		PO ₄ ³⁻	Regulated by Decision 879 for assessing impacts of domestic wastewater and agricultural wastewater		
14	Iron	Fe	For assessing impacts of natural geological conditions, industries	Atomic absorption spectrometry (AAS)	
15	Toxic	Cd	For assessing impacts of industries on river water quality	spectrometry measurements	
16		Cr ³⁺			
17		Cr ⁶⁺			
18		Cu		Atomic absorption spectrometry (AAS)	
19		Ni			
20		Pb			
21		Zn			
22		As			
23		Hg		Cold vapor techniques, atomic absorption spectrometry (AAS)	
24		CN ⁻		Spectrometry measurement	
25		Phenol		Distillation & spectrometry measurements in aqueous solution	
26	Pesticide	Pesticide	For assessing pollution impacts of cultivation activities	Solid phase extraction, gas chromatography GC-ECD	Institute for Marine Environment & Resources
27	Oil	Oil&grease	For assessing pollution impacts of waterway transportation and industrial activities	Infrared spectroscopy	HACEM
28	Microbial	Fecal coliform	For assessing pollution impacts of domestic and livestock raising wastewater	Multiple tube fermentation method	
29		Total coliform	Regulated by Decision 879, this parameter is measured for assessing pollution by domestic		

No	Type	Parameter	Selection reasons	Analysis method	Analysis unit
			and livestock raising wastewater		

4.3 Monitoring time and frequency

4.3.1 Monitoring frequency

Monitoring frequency: 6 times/year

Sampling time: February, April, June, August, October and December.

According to the guidance of Circular 29/2011/TT-BTNMT related to river flow regime, rainfall of Hai Phong city, monitoring frequency of Re river is proposed to be 6 times/year, with 3 times of sampling in rainy season and 3 times of sampling in dry season. Sampling time is February, April, June, August, October and December; thus, in dry season, sampling is taken in December, February and April and in rainy season in June, August and October. Such proposed monitoring frequency and time could help monitor seasonal impacts on river water quality.














4.3.2 Temporal boundary




Sampling will be done during daytime from 8 a.m to 5 p.m.

4.3.3 Time frame for the monitoring plan

Environmental monitoring in 2013 is planned to be done in 6 periods, specifically as follows:

Table 4.3: Specific time frame of Re river monitoring plan

Month Period	Jan	Feb.	Mar	Apr	May	Jun	Jul	Aug.	Sep.	Oct.	Nov.	Dec.	Jan/ 2014	Feb/ 2014
I														
II														
III														
VI														
V														
VI														

 : Preparation, monitoring and sampling.
 : Aggregation and reporting
 : Aggregation and reporting for 2013

4.4 Practical constraints

Constraints of actual conditions possibly affecting the monitoring plan need to be checked before the implementation of the plan. Table 4.4 shows some constraints that may influence accessibility to sampling location.

Table 4.4: Constraints of actual conditions possibly influencing the monitoring plan

Type	Constraints	Description	How to overcome
Internal	Human resources	<i>No information</i>	
	Equipment		
	Chemical		
External	Accessible to sampling location.	It is difficult to get access to sampling points of SR-1, SR-2, SR-3 by car due to small roads; it is necessary to check this accessibility before the sampling	
	Travelling time	Two days are required for sampling at 8 sampling points	There are two teams involved in sampling in a day

4.5 Sampling method

Water samples will be taken along the transects of the river using specialized sampling equipment. After being collected, dependent on the analysis requirements of each parameter, water samples are preserved by different chemicals or in different conditions following TCVN. Sample preservation techniques are applied in accordance with TCVN 6663-3:2008 and detailed in table 4.5.

Besides the 6 parameters directly measured in the field, there are 23 other parameters that need measuring in the laboratory. Therefore, samples used for analysis of these 23 parameters should be preserved applying the method in table 4.5 below.

Table 4.5: Summary of sampling methods applied to different parameters

No	Parameter	Sampling bottle (*)	Method of preservation	Volume (mL)	Preservation time
1	TSS	P or G	1–5 °C	100	24 hours
2	COD	P or G	H ₂ SO ₄ pH = 1–2, 1–5 °C	100	7 days
3	BOD ₅ (20 ⁰ C)	P or G	1–5 °C, dark	500	24 hours
4	NH ₄ ⁺	P or G	H ₂ SO ₄ pH<2, 1–5 °C	500	24 hours
5	NO ₃ [–]	P or BG	1–5 °C	250	24 hours
6	NO ₂ [–]	P or G	1–5 °C	200	24 hours
7	PO ₄ ^{3–}	G	1–5 °C	100	48 hours
8	Fe, Cd, total Cr, Cu, Ni, Pb, Zn	P	HNO ₃ pH<2, 1–5 °C, dark	500	1 month
9	As	P	HNO ₃ /HCl pH<2, 1–5 °C	100	1 month
10	Hg	P	HNO ₃ pH<2, 1–5 °C	1000	1 month

No	Parameter	Sampling bottle ^(*)	Method of preservation	Volume (mL)	Preservation time
11	Cr ⁶⁺	P	NaOH pH>8, 1–5 °C	1000	24 hours
12	CN ⁻	P or G	NaOH pH > 12, 1–5 °C, dark	500	24 hours
13	Phenol	P or G, with PTFE lined cap	H ₂ SO ₄ pH<4, 1–5 °C	1000	21 days
14	Pesticides	G, with PTFE lined cap	1–5 °C	1000	5 days
15	Oil&grease	G	HCl pH = 1–2, 1–5 °C, dark	1000	1 month
16	Fecal coliform	Sterilized G	1–5 °C	100	24 hours
17	Total coliform	Sterilized G	1–5 °C	100	24 hours

^(*) P: Plastic (PE, PVC, PTFE, PET); G: Glass

4.6 Analysis method

4.6.1 Field measurement

Parameters measured right in the field are temperature, pH, turbidity, EC, DO, and salinity. Methods and equipment used to measure these parameters are presented in table 4.6.

Table 4.6: Field equipment and methods

No	Parameter	Method	Equipment
1	Temperature	APHA 2550B	Multiparameter meter (Horiba U-52, Japan)
2	Conductivity		
3	Salinity	APHA 2520 B, C, D	
4	pH	TCVN 6492: 2010	
5	DO	ISO 5418: 1990	
6	Turbidity	TCVN 6184: 2008	

4.6.2 Laboratory analysis

There are 23 parameters analyzed in the laboratory. Methods and equipments employed for measuring these parameters are seen in table 4.7.

Table 4.7: Analysis methods and equipments used in the laboratory

No	Parameter	Method	Equipment	Detection limit	
				Unit	Value
1	TSS	APHA 2540 D	Drying oven (Memmet UM400, Germany); analytical balance (Sartorius BP 210, Germany, d=0.01g)	mg/l	2.9
2	COD	APHA 5220 D	COD reactor (USA); spectrophotometer (HACH DR/4000, USA)	mg/l	5.0
3	BOD ₅ (20°C)	TCVN 6001-1:2008	Dissolved oxygen meter (YSI 52, Japan); BOD incubator (HACH 205,	mg/l	2.5

			USA)		
4	NH ₄ ⁺	TCVN 6179-1:1996	Spectrophotometer (HACH DR/4000, USA)	mg/l	0.05
5	NO ₃ ⁻	TCVN 6180:1996		mg/l	0.23
6	NO ₂ ⁻	APHA 4500-NO ₂ ⁻ B		mg/l	No information
7	PO ₄ ³⁻	TCVN 6202:2008		mg/l	
8	Fe	APHA 3111 B	Atomic absorption spectrometer (Shimazu AA-7000 F/AAC, Japan)	mg/l	
9	Cd	APHA 3113 B or APHA 3111 B		mg/l	0.003
10	Total Cr	APHA 3111 B		mg/l	No information
11	Cr ⁶⁺	APHA 3500-Cr B		mg/l	
12	Cu	APHA 3113 B or APHA 3111 B		mg/l	0.005
13	Ni			mg/l	No information
14	Pb			mg/l	0.003
15	Zn	APHA 3111 B		mg/l	0.005
16	As	APHA 3114 B (hydride generation method) or APHA 3113 B		mg/l	No information
17	Hg	APHA 3112 B		mg/l	
18	CN ⁻	APHA 4500 CN ⁻ C & E	mg/l		
19	Phenol	APHA 5530 D	mg/l		
20	Chlorinated pesticides	AOAC 990.06: 2000	Gas chromatography GC-ECD (HP 6890)	ng/l	
21	Oil&grease	APHA 5520 C	Oil analysis equipment (OCMA 350, HORIBA, Japan)	mg/l	0.2
22	Fecal coliform	TCVN 6187-2:1996 (ISO 9308-2:1990)	Incubator (ShellLab 1535, England), Autoclave, Laminair	MPN/100ml	
23	Total coliform			MPN/100ml	2

Required detection limits for laboratory analysis methods are presented in section 5.3 of the following chapter.

4.7 Quality assurance (QA) and quality control (QC)

Quality assurance and quality control are conducted by HACEM in all monitoring activities.

4.7.1 Field monitoring activities

(1) Quality assurance (QA)

QA activities necessary for field monitoring are listed in table 4.8.

Table 4.8: Field monitoring QA activities

Items	Specific QA activities
Sampling time and frequency	Ensuring appropriate sampling time and frequency
Sampling	<ul style="list-style-type: none"> • Sampling procedures: follow TCVN • Methods of sample treatment and preservation: follow TCVN • Sample bottles: are selected dependent on monitoring parameters following TCVN • Sample bottle labels: should cover sufficient informaton, and attatched to the bottles during sample existance. • Field analysis methods: follow TCVN • Field record format
Equipment	<ul style="list-style-type: none"> • Use of suitable equipments to determined measurement, experimental methods; the equipments have to meet the requirements of the methods in terms of techniques and measurement. • The same equipment should be used at different monitoring points under the same monotirng plan. • Equipments are ensured to be enclosed with use instructions, necessary information and to be maintained and calibrated before they are used in the field.
Sample transportation& preservation	<ul style="list-style-type: none"> • Follow TCVN 6663-3:2008
Human resources	<ul style="list-style-type: none"> • Qualified sampling team is mobilized. • Specific tasks are assigned to each member and in written documents.

(2) Quality control (QC)

In order to control quality during sampling, treatment and preservation in the field, the following QC samples are used:

- Container blank samples,
- Field blank samples.

4.7.2 Laboratory analysis activities

Activities of the laboratory of the centre are conducted in accordance with ISO/IEC 17025-2005.

(1) Quality assurance (QA)

QA activities for laboratory analysis are listed in table 4.9.

Table 4.9: Analysis QA activities in the laboratory

Items	Specific activities
General	Specific work is implemented based on guidance documents
Equipment	<ul style="list-style-type: none"> • Equipment of the laboratory is calibrated before being used. • Laboratory equipment is marked & labelled favorable for identification. • The labels show calibration status, next calibration time of the equipment.
Sample management	<ul style="list-style-type: none"> • Application of sample management procedures suitable for each parameter. • Sample identification symbols are maintained during sample existence in the laboratory during the analysis. • After being analyzed, samples are kept and preserved for one week for re-check if necessary.
Human resources	<ul style="list-style-type: none"> • Clear organizational structure of the laboratory, • Officials, technicians, and quality managers are assigned with specific responsibilities and duties.

(2) Quality control (QC)

Use of QC samples, including:

- Equipment blank samples,
- Method blank samples,
- Replicate/duplicate sample,
- Spike samples,
- Certificate standard samples,
- Control standard samples.

4.8 Sampling units

Table 4.10 describes sampling units including sample volume for analysis, back-up sample volume, and QA/QC sample volume for each parameter.

Table 4.10: Sampling units for each parameter in Re river monitoring plan

Parameter	Sample volume for analysis (mL)	Volume of back-up sample (mL)	Total volume (mL)
TSS	100	100	200
COD	100	100	200
BOD ₅ (20 ⁰ C)	500	500	1000
NH ₄ ⁺	500	500	1000
NO ₃ ⁻	250	250	500
NO ₂ ⁻	200	200	400
PO ₄ ³⁻	100	100	200
Fe, Cd, total Cr, Cu, Ni, Pb, Zn	500	500	1000
As	100	100	200
Hg	1000	1000	2000
Cr ⁶⁺	1000	1000	2000
CN ⁻	500	500	1000
Phenol	1000	1000	2000
Pesticides	1000	1000	2000
Oil&grease	1000	1000	2000
Fecal coliform	100	100	200
Total coliform	100	100	200
Total (mL)			16,100

CHAPTER 5 METHOD OF DATA ANALYSIS

5.1 Summarized results of each parameter

Result of water quality parameters is single value obtained from analysis of a unique sample in each sampling period.

The obtained value will be compared with QCVN using normal “greater than” or “less than” techniques to draw a conclusion on quality of river water in each sampling period.

5.2 Required standards for river water quality

As the entire Re river is used as a water supply source for domestic water factories and agricultural sector, its water quality is required to meet a level of A2 of QCVN 08:2008/BTNMT to a minimum.

5.3 Required detection limit

Detection limit required for the analysis methods used in the monitoring plan of section 4.5 should be 10-20% lower than the applied action level. Action levels and required detection limits by parameter are described in table 5.1.

Table 5.1: Required detection limits applied to analysis methods in the laboratory

Parameter	Unit	Applied action level (QCVN 08)	Required detection limit	Actual detection limit	Analysis method (to achieve required detection limit)
		A2			
Temperature	°C	-			
Conductivity	mS/m	-			
Salinity	ppt	-			
pH	-	6-8,5			
DO	mg/L	≥ 5	0.5		
Turbidity	NTU	-			
TSS	mg/L	30	0.3	2.9	
COD	mg/L	15	1.5	5.0	
BOD ₅ (20°C)	mg/L	6	0.6	2.5	
NH ₄ ⁺ -N	mg/L	0,2	0.02	0.05	
NO ₃ ⁻ -N	mg/L	5	0.5	0.23	
NO ₂ ⁻ -N	mg/L	0.02	0.002		
PO ₄ ³⁻ -P	mg/L	0.2	0.02		
Fe	mg/L	1.0	0.1		
Cd	mg/L	0.005	0.0005	0.003	
Cr ³⁺	mg/L	0.1	0.01		
Cr ⁶⁺	mg/L	0.02	0.002		
Cu	mg/L	0.2	0.02	0.005	
Ni	mg/L	0.1	0.01		
Pb	mg/L	0.02	0.002	0.003	
Zn	mg/L	1.0	0.1	0.005	
As	mg/L	0.02	0.002		
Hg	mg/L	0.001	0.0001		
CN ⁻	mg/L	0.01	0.001		
Phenol	mg/L	0.005	0.0005		
Pesticides	µg/L				

Parameter	Unit	Applied action level (QCVN 08)	Required detection limit	Actual detection limit	Analysis method (to achieve required detection limit)
		A2			
Oil&grease	mg/L	0.02	0.002	0.2	
Fecal coliform	MPN/100 mL	50	5		
Total coliform	MPN/100 mL	5000	500	2	

CHAPTER 6 BUDGET FOR MONITORING ACTIVITIES

Budget for Re river monitoring plan activities is estimated in detail in table 6.1 below.

Table 6.1: Estimated budget for Re river monitoring plan in 2013

Monitoring activities	Details	Quantity	Cost
Survey for selection of monitoring sites (1,825,000)	Car rent for the survey	One survey x 1,500,000 VND/survey	1,500,000
	Survey participation	5 people x 65,000 VND/head	325,000
Sampling (30,138,000)	Sample & monitoring equipment transportation, sampling	1,500,000 VND/day x 1 day/per sampling trip x 6 times of sampling/year	9,000,000
	Boat rent	300,000 VND/each time x 8 sampling points/river x 6 times/year	14,400,000
	Purchasing sample bottles and ice for sample preservation	50,000 VND/each time x 8 sampling points/river x 6 times/year	2,400,000
	Battery for monitoring instruments	4 pairs x 50,000 VND	200,000
	Gloves	2 boxes x 6 times/year x 60,000 VND/box	720,000
	Tissues	5 boxes/each time x 6 times/year x 15,000 VND/box	450,000
	Field monitoring	6 people x 65,000 VND/people x 1 day/per monitoring time x 6 times/year	2,340,000
Stationeries	Pencils	2 boxes x 50,000 VND/box	100,000
	Field record books	2 books x 20,000 VND /books	40,000
	Undeletable pens	8 pens x 20,000 VND/pen	160,000
	Notepaper	4 files x 7,000 VND/file	28,000
	Sample bottle label	20 label file x 15,000 VND /file	300,000
Sample analysis in the laboratory (131,280,000)	Outsourced analysis (of parameters that HACEM could not analyze)	Once/per outsourced analysis x 200,000 VND/ per outsourced analysis x 6 times of outsourced analysis/year)	1,200,000
	Parameter analysis (attatched appendixes)		130,080,000

Monitoring activities	Details	Quantity	Cost
Synthesis and annual reporting			12,000,000
Total			175,243,000

Detailed estimated budget for analysis of each parameter is shown in table 6.2.

Table 6.2: Estimated budget for sample analysis

No	Parameter	Unit price (VND)	Monitoring analysis/year	No of monitored rivers	Sample No/river/sampling trip	Total samples/year	Total (VND)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(3) x (7)
1	Temperature	30,000	6	1	8	48	1,440,000
2	Conductivity	40,000	6	1	8	48	1,920,000
3	Salinity	40,000	6	1	8	48	1,920,000
4	pH	30,000	6	1	8	48	1,440,000
5	DO	60,000	6	1	8	48	2,880,000
6	Turbidity	50,000	6	1	8	48	2,400,000
7	TSS	50,000	6	1	8	48	2,400,000
8	COD	70,000	6	1	8	48	3,360,000
9	BOD ₅	80,000	6	1	8	48	3,840,000
10	NH ₄ ⁺	60,000	6	1	8	48	2,880,000
11	NO ₃ ⁻	50,000	6	1	8	48	2,400,000
12	NO ₂ ⁻	50,000	6	1	8	48	2,400,000
13	PO ₄ ³⁻	60,000	6	1	8	48	2,880,000
14	Fe	60,000	6	1	8	48	2,880,000
15	Cd	60,000	6	1	8	48	2,880,000
16	Cr ³⁺	60,000	6	1	8	48	2,880,000
17	Cr ⁶⁺	60,000	6	1	8	48	2,880,000
18	Cu	60,000	6	1	8	48	2,880,000
19	Ni	60,000	6	1	8	48	2,880,000
20	Pb	60,000	6	1	8	48	2,880,000
21	Zn	60,000	6	1	8	48	2,880,000
22	As	80,000	6	1	8	48	3,840,000
23	Hg	80,000	6	1	8	48	3,840,000
24	CN-	80,000	6	1	8	48	3,840,000
25	Phenol	300,000	6	1	8	48	14,400,000
26	Chlorinated pesticides	600,000	6	1	8	48	28,800,000

(6-2)

No	Parameter	Unit price (VND)	Monitoring analysis/year	No of monitored rivers	Sample No/river/sampling trip	Total samples/year	Total (VND)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(3) x (7)
27	Total oil&grease	300,000	6	1	8	48	14,400,000
28	Fecal coliform	60,000	6	1	8	48	2,880,000
29	Total Coliform	60,000	6	1	8	48	2,880,000
Total							130,080,000
<i>(One hundred thirty million and eighty thousand dong)</i>							
Budget estimation is based on: Circular No 83/2002/BTC, dated 25/Sep./2002 by Ministry of Finance stipulating fee collection, payment and management.							

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APPENDICES

Table P-1: Pumping stations operating at An Kim Hai irrigation system

No	Station name	Address	Operation scope	No of pumps	Designed volume per pump (m ³ /h)
1	Cu	Le Thien commune – An Duong district	01 commune	1	1200
2	Le Thien	Le Thien commune –An Duong district	Inter-commune	2	1200
3	Du Nghia 1	Le Thien commune –An Duong district	01 commune	1	540
4	Du nghia 2	Le Thien commune –An Duong district	01 commune	1	540
5	Kim Son	Le Thien commune –An Duong district	01 commune	1	540
6	Tien Phong	An Hong commune –An Duong district	01 commune	1	1200
7	Thuan Ty	An Hong commune –An Duong district	01 commune	1	540
8	Cau Dong	An Hong commune –An Duong district	01 commune	1	540
9	An Hung	An Hung commune –An Duong district	01 commune	1	1200
10	Do Nha 1	An Hung commune –An Duong district	Inter-commune	2	1000
11	Do Nha 2	An Hung commune –An Duong district	01 commune	2	1000
12	Dong Hoa	An Hung commune –An Duong district	01 commune	1	1000
13	Dong Thanh	An Hung commune –An Duong district	01 commune	1	540
14	Tinh Thuy	An Hoa commune – An Duong district	01 commune	1	1200
15	Ngo Duong	An Hoa commune – An Duong district	01 commune	2	1000
16	Ha Nhuan	An Hoa commune – An Duong district	01 commune	2	1500
17	An Hoa	An Hoa commune – An Duong district	Inter-commune	2	1500
18	Dam La	An Hoa commune – An Duong district	01 commune	1	540
19	Ben Tam	An Hoa commune – An Duong district	01 commune	1	540
20	Giua Dong	An Hoa commune – An Duong district	01 commune	1	540
21	Tan Tien	Tan Tien commune –An Duong district	Inter-commune	1	1200
22	Dong Ngo	Tan Tien commune –An Duong district	01 commune	1	700
23	Dong Thap	Tan Tien commune –An Duong district	01 commune	1	540
24	Phung Duong	Hong Phong commune –An Duong district	Inter-commune	2	1200
25	Ho Dong	Hong Phong commune –An Duong district	01 commune	1	1200
26	Ba Mieu	Hong Phong commune –An Duong district	01 commune	1	700
27	Dinh Ngo	Hong Phong commune –An Duong district	01 commune	1	700
28	Van Cu	An Dong commune–An Duong district	01 commune	1	540
29	Vinh Khe	An Dong commune–An Duong district	01 commune	1	750
30	Cai Tat	An Dong commune–An Duong district	01 commune	1	1200
31	Van Tra I	An Dong commune–An Duong district	01 commune	1	1000
32	Van Tra II	An Dong commune–An Duong district	01 commune	1	700
33	Bac Ha	Bac Son commune –An Duong district	01 commune	1	1000
34	Dong Phan	Bac Son commune –An Duong district	01 commune	2	1500
35	Dinh Nam	Bac Son commune –An Duong district	01 commune	1	700
36	Nam Ha	Bac Son commune –An Duong district	01 commune	1	700

No	Station name	Address	Operation scope	No of pumps	Designed volume per pump (m ³ /h)
37	Cong My	Nam Son commune –An Duong district	01 commune	1	540
38	Nam Son	Nam Son commune –An Duong district	01 commune	1	750
39	Hong Thai	Hong Thai commune –An Duong district	01 commune	1	1200
40	Xich Tho	Hong Thai commune –An Duong district	01 commune	1	700
41	Dao Yeu	Hong Thai commune –An Duong district	01 commune	1	540
42	Hy Tai 1	Hong Thai commune –An Duong district	01 commune	1	700
43	Kieu Trung II	Hong Thai commune –An Duong district	01 commune	1	1800
44	Doan Ket	Hong Thai commune –An Duong district	01 commune	1	2500
45	Bach Mai	Dong Thai commune –An Duong district	Inter-commune	3	1800
46	Dong Bui	Dong Thai commune –An Duong district	01 commune	1	1800
47	Dang Cuong	Dang Cuong commune –An Duong district	01 commune	1	1200
48	Hong Tuan	Quoc Tuan commune – An Duong district	Inter-commune	2	1200
49	Quoc Tuan	Quoc Tuan commune – An Duong district	01 commune	2	540
50	Kieu Thuong	Quoc Tuan commune – An Duong district	01 commune	1	540
51	Quan Nga	Quoc Tuan commune – An Duong district	01 commune	1	1000
52	Nhu Kieu	Quoc Tuan commune – An Duong district	01 commune	1	2x2500+1500
53	Ha Lien	Le Loi commune –An Duong district	Inter-commune	3	750
54	Vuon Vai	Le Loi commune –An Duong district	01 commune	1	1000

Location of monitoring points in a connection with water intake stations and pollution sources along Re river is shown in figure P-1 to figure P-3 as follows.

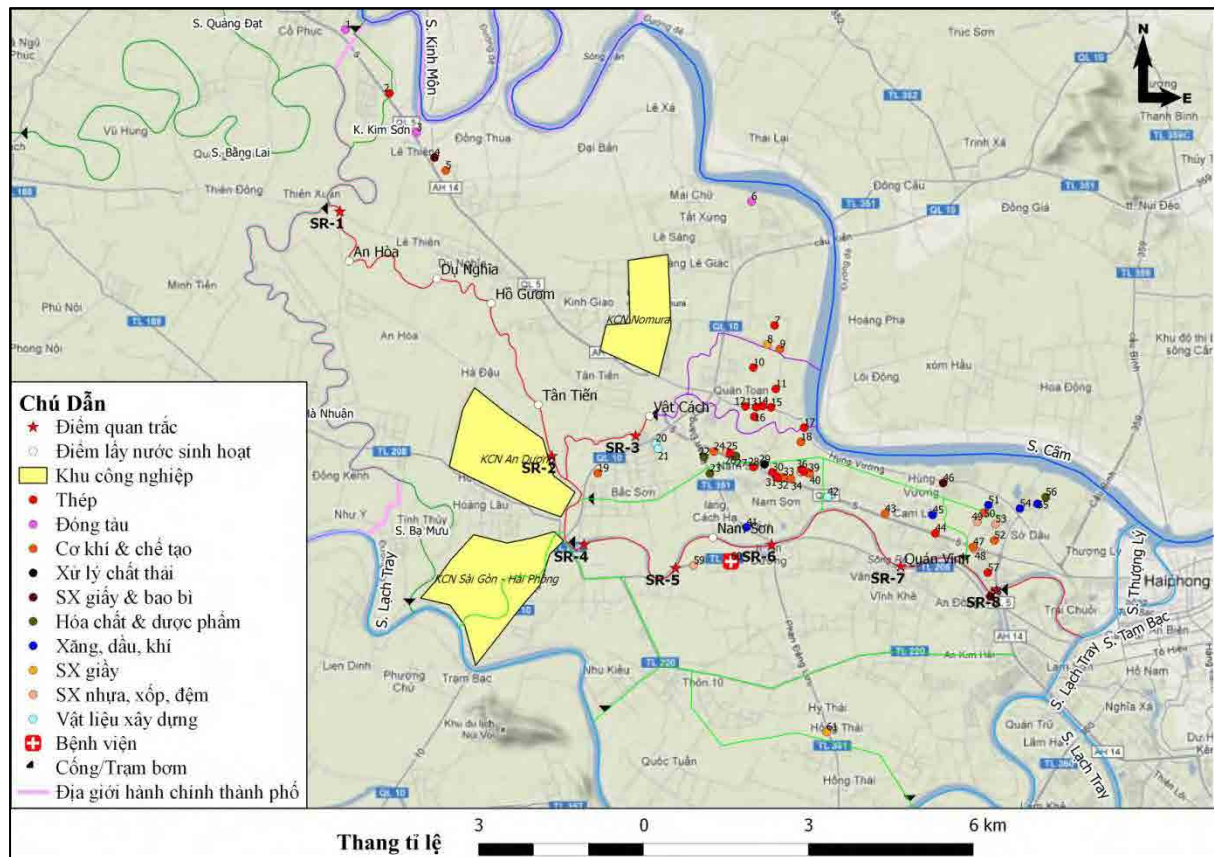


Fig. P-1: Monitoring points of SR-1 to SR-8 in Re river

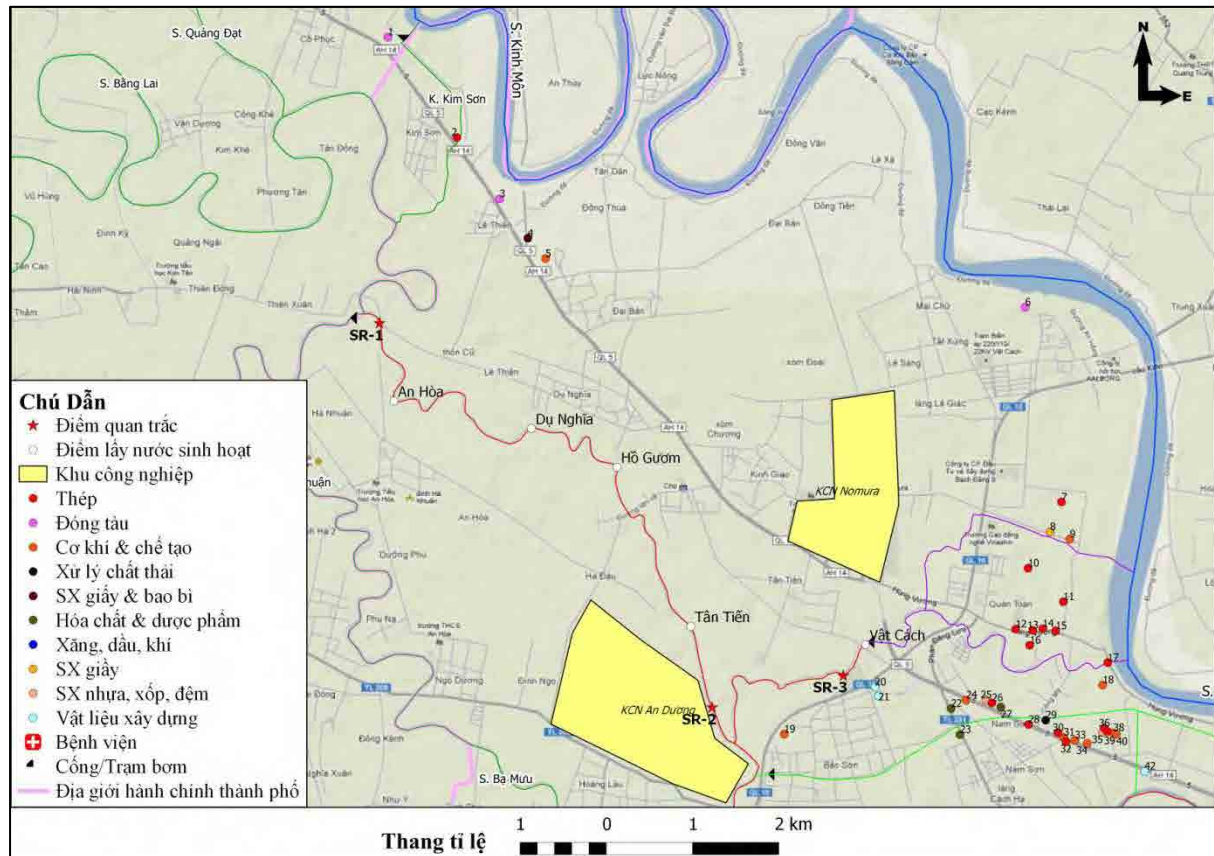


Fig. P-2: Monitoring points of from SR-1 to SR-3 in Re river (zoomed out).

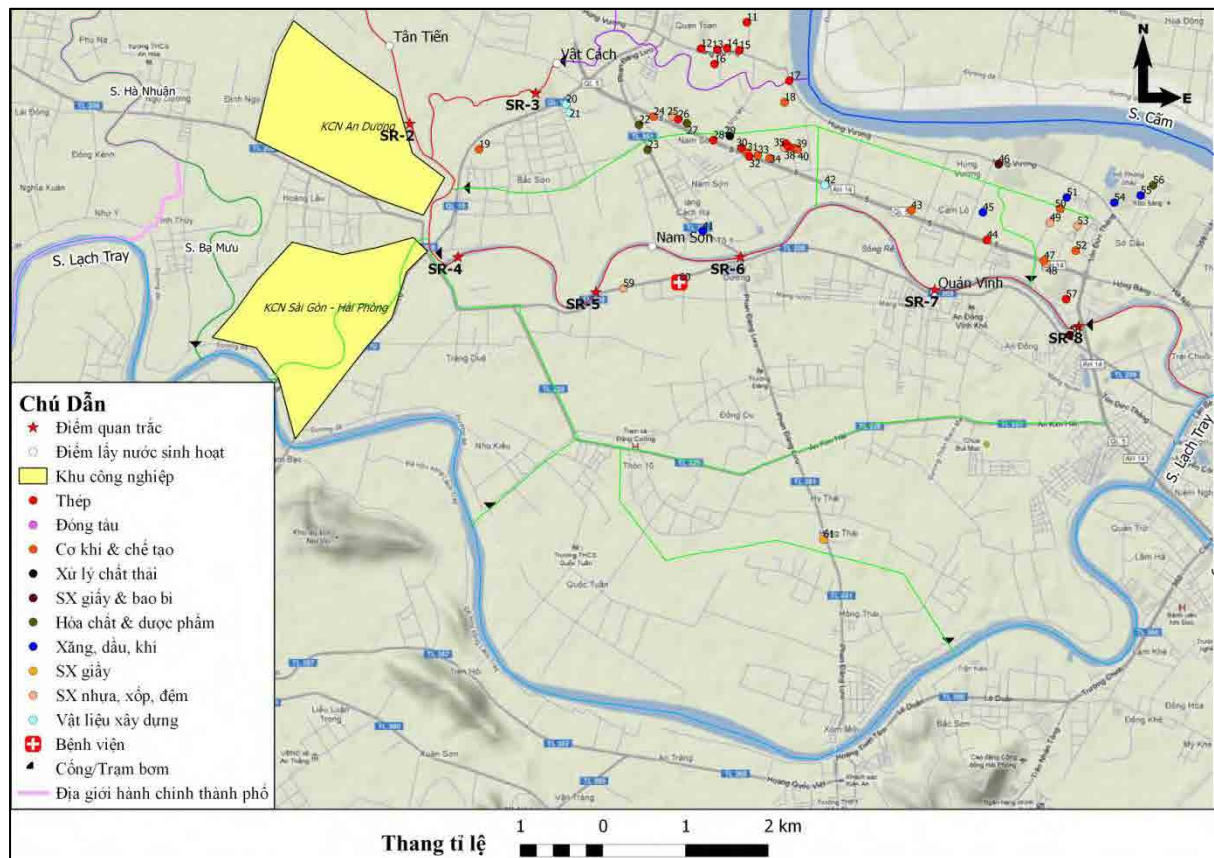


Fig. P-3: Location of monitoring points of from SR-4 to SR-8 in Re river (zoomed out).

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SOCIALIST REPUBLIC OF VIETNAM

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

**The Project for
Strengthening Capacity of Water
Environmental Management in Vietnam**

**The DQO-based Water Quality Monitoring Plan for
Huong river, Thua Thien – Hue province**

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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/QĐ-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, economic-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 then issued as a to the respective DONRE for them to turn into a monitoring program and subsequently implement.

The Project

1.2 Purpose of this document

The purpose of this document is to define the basis for the monitoring carried out at City level by the Ho Chi Minh City's Centre for Environmental Monitoring and Analysis, under Environmental Protection Agency, Department of Natural Resources and Environment . 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-4¹. 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.

¹ Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. United States Environmental Protection Agency. Office of Environmental Information Washington, DC 20460. EPA/240/B-06/001 February 2006.

CHAPTER 2. OBJECTIVES AND RESOURCES FOR MONITORING PLAN

2.1 Status of water quality in Huong river

Huong river is a main domestic water supply source for Hue city and residential areas in the province where a number of water factories are located along the river. In addition, according to Irrigation Department under DARD of Thua Thien Hue, water from Huong river system is used for irrigating 22,000 ha of agricultural land. Moreover, Huong river with diverse scenic beauty along the two river banks is a famous destination for domestic and foreign tourists; therefore, water protection of Huong river is of great importance to socio-economic development of the province. Nevertheless, in recent years, Huong river water has been degraded in quality due to various reasons as presented in the table below.

Table 1: Summaized issues related to Huong river water quality, Thua Thien – Hue province

Water quality issues	Location	Causes	Information source
Local pollution, increase in BOD5, COD, Nitrogen and phosphor, reduction in DO, especially in dry season.	Huong river section running through Hue city, river branches of Pho Loi, Loi Nong, Nhu Y ...	Untreated domestic wastewater from two river banks	Management Board for Huong river project (2008) EPA of TT-Hue (2010)
Increased Coliform	In Van Nien water factory and Xuoc Du bridge area, the Coliform parameter only meets A2 grade; the remaining locations witness water quality meeting B2 grade of QCVN 08	Untreated domestic wastewater from two river banks	EPA of TT-Hue (2010)
TSS concentration exceeding A1-QCVN 08	Huong river	Unknown, possibly caused by sand exploitation?	EPA of TT-Hue (2010)
Pollution caused by industrial wastewater leads to an increase in concentrations of BOD, COD, heavy metal...	Point sources dispersedly found along Huong river	Wastewater from some factories situated along Huong river banks namely Huda beer factory, Long Tho cement factory, Huong river seafood import and export company, Ga Loi quarry, titanium processing plant	Management of Huong river (2008)
Pollution caused by agricultural activities	Huong river downstream: from the area behind Hue city to Thao Long weir, rice cultivation area on the two banks of Bo river	Such components as organic nitrogen, organic phosphate, organic humus ... are derived from the decomposition of pesticides, agricultural wastes (straw, plants...)	Management Board for Huong river project (2008)
Pollution caused by solid waste released into the river	At the beginning point of Nhu Y river and Dai Giang river	Average quantity of discharged rubbish per capita in Hue city is around 0.35 – 0.4 kg/people/day; yet, due to low awareness of local people, indiscriminate waste/rubbish discharge results in environmental pollution	Management Board for Huong river project (2008)
Manganese concentration in 2010 was 19 times higher, and iron concentration was 2.6 times higher compared with the	Huong river downstream area – the section running through Hue city and its vicinity	Binh Dien hydropower reservoir bottom had not been cleaned before it was stocked with water and came into operation in May 2009. The	Nguyen Dinh Hoe et al. (2010) TT-Hue water supply company

Water quality issues	Location	Causes	Information source
year 2008.		reservoir did not have bottom discharge system.	(2011)
BOD, COD exceeding the standard level applied to surface water	Tam Giang lagoon area	The causes have not been identified (due to aquaculture or domestic wastewater from upstream area?). It is not been made clear about which QCVN to apply for lagoon water	TT-Hue EPA (2010)

2.2 Overall information on the monitoring plan

2.2.1 Objectives of the monitoring plan

Water quality monitoring plan for Huong river is developed and implemented to reply to the following questions:

- 1) Central question: Which river sections witness water quality not meeting Viet Nam's standard for the expected use purposes?
- 2) Sub- question 1: Are there longitudinal changes in river water quality?
- 3) Sub- question 2: Are there temporal changes in water quality in a given location? For example, after the establishment of wastewater treatment plant or implementation of measures for pollution control, has water quality been improved?

Note: These questions may be applied when budget and analyzed data are sufficient to provide answers to these questions. If not, only the central question is required.

2.2.2 Actions taken to given answers to these questions

Environmental Monitoring Station is in charge of Huong river water quality monitoring plan and under EPA, and under the management of DONRE of Thua Thien Hue Province. TT-Hue DONRE's tasks are presented in Decision No 1861/2003/QD-UB dated 08/7/2003 by Thua Thien Hue Province's People's Committee as follows:

- *Organize the regular assessment of current environmental status in the locality; survey and determine the area where the environment is polluted; make a list of environmental pollution entities, serious environmental pollution entities in the locality and submit regular reports to Provincial People's Committee and MONRE in accordance with laws and regulations; check the implementation environmental pollution countermeasures of those entities;*
- *Hosting or coordinating with related agencies in building and organizing the implementation of the plan for resource mobilization with a view to reponsing to and overcoming environmental pollution caused by environmental incidents as assigned by Provincial People's Committee;*

Therefore, the implementation of environmental monitoring plan is one of the key tasks aimed at regularly evaluating the current environmental status of the locality to identify environmentally polluted areas and pollution level. The areas suffering from environmental pollution (with one or many parameters exceeding QCVN) will be kept informed by the Environmetnal Monitoring Station in the form of reporting/written documents waiting for the follow-up responses.

2.2.3 Type of monitoring and scope of the monitoring plan

- Water monitoring plan for Huong river only covers the monitoring of surface water.
- Spatial scope: this plan is aimed to monitor surface water quality of some main rivers in Huong river basin, including Ta Trach river, Huu Trach river and Huong river section running through Hue city and Bo river.
- Temporal scope: the monitoring plan lasts for one year from 1/January/2013 to 1/January/2014

2.3 Resources for the monitoring plan

2.3.1 Budget for the monitoring plan

The water quality monitoring plan for Huong river is a part of environmental monitoring plan for the whole Thua Thien Hue province. In 2012, the budget for the implementation of the monitoring plan is broken down below:

Table 2: Budget for implementation of the environmental monitoring plan of TT-Hue province in 2012

			Budget (million VND)
Environmental monitoring			613.5
1	Field survey, identification of monitoring points	Survey, sampling: 5 people x 30 days x 40,000 VND/day = 6,000,000 VND	6.0
2	Sample preservation	Cost for sample preservation: 160,000/VND x 3 months = 480,000 VND	480.0
3	Hiring travelling means for survey and sampling	Car rent for survey, sampling: 2500 km/quarter x 18 litre/100 km x 21,000 VND/litre = 9,450,000 VND Boat rent for survey, sampling: 750,000 VND/trip x 3 trips = 2,250,000 VND	11.7
4	Stationeries	Film/photos, stationeries, communication: 700,000 VND/month x 03 months = 2,100,000 VND	2.1
5	Monitoring work		108.7
5.1	Surface water quality monitoring: Monitoring parameters : 12 parameters (pH, DO, turbidity, conductivity, SS, COD, BOD5, Cl-, Fe, coliform, NO3-, PO42-); cost estimated for analysis of 01 sample: 670,000 VND/sample	Monitoring points: 70 points 1. Huong river basin: 8 points 2. Huong river distributaries (Dong Ba river, Bach Yen river, Ke Van river, Loi Nong river): 8 points 3. Trench around the city (sewer gates of Thuong Tu, Dong Ba, Hau, An Hoa, Vinh Loi, Cau Kho): 6 points 4. Lakes/ in inner city (hồ trong thành nội) (Tay Loc, Thuan Hoa, Thuan Loc, Thuan Thanh): 4 points 5. Gold mining area (hydropower reservoir): 2 points	46.9

		6. Phong Dien titanium mineral mining area: 2 points 7. Bo river basin, Huong Van commune, Huong Tra district: 4 points 8. O Lau river: the boundary of the two provinces: Quang Tri and Thua Thien Hue: 4 points 9. Nong river basin: 3 points 10. Truoi river basin: 3 points 11. Bu Lu river basin: 3 points 12. Ta Trach river basin: 3 points 13. Tinh Tam reservoir: Centre of Hue city 14. Chau Son reservoir: Water supply reservoir for Huong Thuy district 15. Tam Giang Lagoon: 6 points 16. Cau Hai lagoon, Phu Loc district: 4 points 17. Thuy Tu lagoon, Phu Vang district: 4 points 18. Lang Co lagoon Lang Co, Phu Loc district: 4 points 670,000 VND/sample x 70 = 46,900,000 VND	
5.2	Groundwater environmental quality monitoring: Monitoring parameters: 12 (pH, DO, turbidity, conductivity, SS, COD, BOD ₅ , Cl ⁻ , Fe, Coliform, NO ₃ ⁻ , SO ₄ ³⁻)	Monitoring points (20 points): 1. Hue city: + Inner: 2 points and outer: 2 points 2. 08 districts: 2 points/district 670,000 VND/sample x 20 samples = 13,400,000 VND	13.4
5.3	Water environment quality monitoring: Monitoring parameters: 12 (pH, DO, turbidity, conductivity, SS, COD, BOD ₅ , Cl ⁻ , Fe, Coliform, NO ₃ ⁻ , PO ₄ ³⁻), cost estimated for analysis of 1 sample: 670,000 VND/sample.	Monitoring points (40 points): 1. Dischagre sewer gate along Huong river: 5 points (Cổng thải dọc sông Hương) 2. Textile and dying entities: 5 points 3. Food processing entities: 4 points 4. Industrial entities and aquaculture area: 4 points 5. Industrial shrimp farming on sand: 10 points 6. Dump site in Hue city: 2 points 7. Restaurants, services: 6 points 8. Construction material production & bussiness entities: 4 points 670,000 VND/sample x 40 samples = 26,800,000 VND	26.8
5.4	Monitoring of noise and air environment quality Monitoring parameters: suspended dusts, noise, CO, SO ₂ , NO ₂ (4 parameters): cost estimated for analysis of 1 sample: (300,000 VND/parameter x 05 = 1,200,000/sample)	Monitoring points (18 points): 1. Phong Thu township, Phong Dien district: in the north of the province: 1 point 2. Tu Ha small-scale industry area & Tu Ha township, Huong Tra district: 2 points 3. Hue city: 7 monitoring points in the four directions of East, West, South and North, Central area and one baseline monitoring point 4. Tan My, Phu Vang belong to Thuan An township: (lagoon bank area, fishery planning and	21.6

		<p>development area, sea ports): 1 point</p> <p>5. Phu Bai industrial park and Phu Bai township: 3 points</p> <p>6. Chan May area: 1 point</p> <p>7. North of Hai Van pass: Lang Co area, Phu Loc district: 1 point</p> <p>8. Khe Tre township, Nam Dong district: 1 point</p> <p>9. A Luoi township, A Luoi district: mountainous area of Thua Thien Hue: 1 point</p> <p>1,200,000 VND/sample x 18 samples = 21,600,000 VND</p>	
5.5	Total cost for sample analysis (air, water ...): 108,700,000 VND/quarter		
6.	Data processing, synthesis and reporting		5.0
	<ul style="list-style-type: none"> - Data processing, documentation, and reporting of current status (surface water, groundwater, wastewater, air) - Data processing, documentation, and generalization report writing 	<ul style="list-style-type: none"> - Data processing, documentation, report writing on current status of surface water environment - Data processing, documentation, report writing on current status of groundwater environment - Data processing, documentation, report writing on current status of wastewater environment - Data processing, documentation, report writing on current status of air environment - Data processing, documentation, generalization report writing 	<p>1.0</p> <p>1.0</p> <p>1.0</p> <p>1.0</p> <p>1.0</p> <p>1.0</p>

Source: Environmental monitoring and analysis station of Thua Thien - Hue province (2012)

2.3.2 Human resource for the monitoring plan

Name	Position	Responsibility	Contact information
Nguyen Hoang Phuoc	Deputy director of EPA/Head of the monitoring station	General management	[Tel][Email]
Nguyen Dinh Phuoc	Officer	Preparation of monitoring plan, data processing, reporting	[Tel][Email]
Dang Phuoc Binh	Officer	Sampling	[Tel][Email]
Nguyen Thi Thanh Thuy	Officer	Analysis	[Tel][Email]
Chau Manh Quynh	Officer	Sampling	[Tel][Email]
Tran Canh Hung	Officer	Sampling	[Tel][Email]

Source: Environmental monitoring & analysis station of Thua Thien - Hue province (2012)

2.3.3 Field and laboratory measurement

By the end of 2011, sampling and analysis in the laboratory were carried out under the contract with the Centre for Technology Transfer & Testing under Department of Science & Technology of Thua Thien Hue Province. The list of field and laboratory equipment of the Centre is presented below (extracted from the Centre capacity file).

- Field equipment

No	Instrument	Origin	Quantity
1	Salinity, conductivity, TDS, temperature measurer	Germany	01
2	DO measurer	Germany	01
3	GPS device	U.S.A	01
4	Portable pH measurer	Germany	01
5	Salinity/density refractometer	U.S.A	01
6	pH/temperature measuring pen	Japan	01
7	pH, O ₂ , NH ₃ , NH ₄ , H ₂ S measuring kit	Germany	05

- Laboratory equipment

No	Instrument	Origin	Quantity
1	Pressurized chromatograph	Japan	01
2	Polarograph	Thụy Sĩ	01
3	Spectrograph	Japan	01
4	Flame photometer	Switzerland	01
5	Coliform, E-Coli test kit	Japan	01
6	6-slot digester	Japan	01
7	Electronic scale	Japan	02
8	Oven 1200 degrees Celsius	China	01
9	Chromatograph system	Japan	01
10	Máy cở quay chân không	Japan	01
11	TOA water quality measurer	Japan	01
12	BOD – Aqualitic analytical instrument	Japan	01
13	COD analytical instrument	Japan	01
14	Bộ chưng cất đậm	Japan	02
15	Tủ hút khí độc	Vietnam	01
16	Tủ sấy	China	01
17	Tủ tiết trung khô	Japan	01
18	Tủ ẩm	Japan	01
19	Tủ tiết trùng ướt	Japan	01
20	Tủ cấy	Japan	01
21	Kính hiển vi 2 mắt	Japan	01
22	Khúc xạ kế	Japan	01
23	Máy đo pH hiện số	Đức	01
24	Máy lắc	Trung Quốc	01

No	Instrument	Origin	Quantity
25	Máy so màu	Tiệp Khắc	01
26	Đèn cực tím	Nhật	01
27	Máy hút âm	Nhật	01

In addition, from 2012, Environmental Monitoring Station of Thua Thien Hue Province is equipped with some instruments for the monitoring plan as follows:

Field equipment

No	Instrument	Model/Origin	Quantity
1	Portable multi parameter analyzer	U-52/ HORIBA, Japan	01
2	DO measurer	OM-51/HORIBA, Japan	01

Laboratory equipment

No	Instrument	Model/Origin	Quantity
1	Water purifier	Aquatron Automatic Water Stills A4000D/ Bibby Scientific - UK	01
2	Spectrophotometer UV-VIS	PhotoLab 6600/ WTW, Germany	01
3	Fume Hoods	EFH-4A1/ ESCO, Singapore	01
4	Thermoreactors for COD	CR-4200/ WTW, Germany	01
5	pH measurer	F-51BW/HORIBA, Japan	01
6	EC mesurer	DS-51/HORIBA, Japan	01
7	Technical scale	PL202-S/Mettler Toledo, Switzerland	01
8	Analytical scale	MS204S/Mettler Toledo, Switzerland	01
9	Magnetic stirrer	RH basic 2/Ikamag, Germany	01
10	Vacuum Pump	LV-125A/Nitto Kohki, Japan	01
11	Incubators	PR205740R/Thermo Scientific, USA	01
12	Universal oven	UNE 550/Memmert, Germany	01

2.4 Temporal boundary for the monitoring plan

The monitoring plan will be implemented for one year from 15/January/2013 to 15/January/2014

CHAPTER 3. NECESSARY INFORMATION FOR MONITORING PLAN DEVELOPMENT

3.1 Natural and social characteristics of Huong river basin

3.1.1 Huong river basin

Huong river basin covers an area of about 2,830 km². The major stream/flow of Huong river is formed from three main river branches: Bo river, Ta Trach river and Huu Trach river and intertwined system of canals in the downstream river area.

- Bo river starts from southwest mountainous forests in A Luoi district. The river is branched at the confluence of Pho Nam, turning into Quang Dien low-lying plain through the branches of An Xuan, Quan Cua; a part the river flow runs into Huong river at Sinh confluence.
- The two branches of Ta Trach and Huu Trach start from the east mountainous forests of Truong Son range in districts of Nam Dong and A Luoi and meet at Tuan confluence. The section from Tuan confluence to Thuan An is called Huong river.

Huong river plain zone enjoys a thick system of rivers, being divided into two parts as follows:

- Distributaries north of Huong river: a system of Hoi Cho canal, An Xuan canal, Quan Cua and horizontal rivers has generated a dense canal irrigation network.
- Distributaries south of Huong river (including three key tributaries):
 - Distributary of Loi Nong – Dai Giang river from Phu Cam gate to Cau Hai lagoon.
 - Distributary of Nhu Y river from Da weir; its water runs into Loi Nong-Dai Giang river.
 - Distributary of Pho Loi river, receiving water from Huong river through La Y sewer gate; and its water runs into Tam Giang-Cau Hai Lagoon.

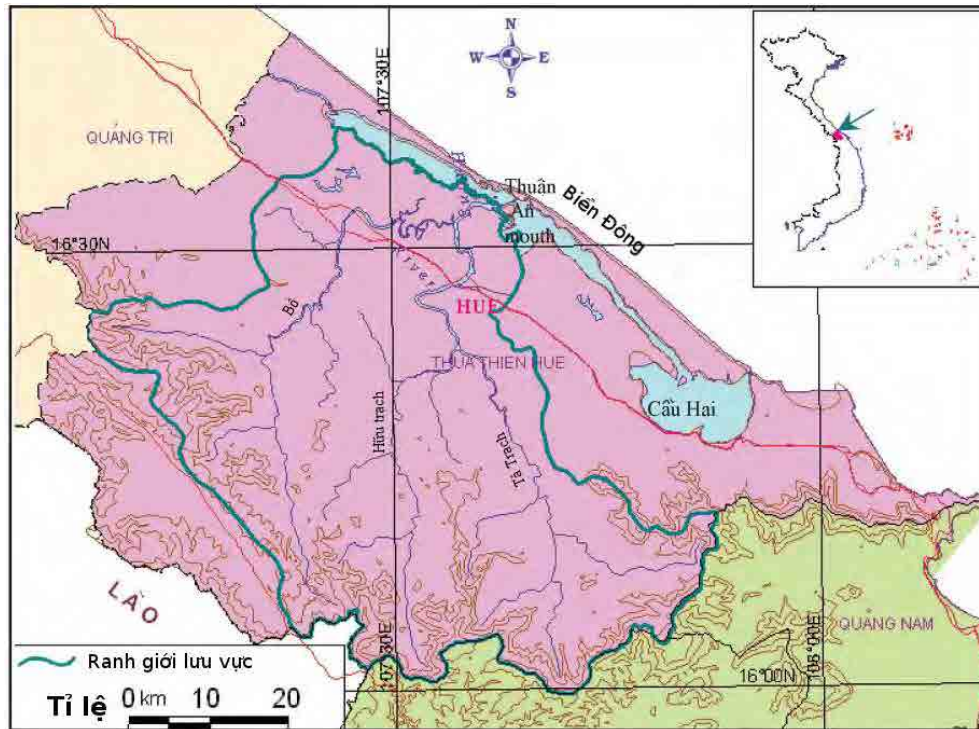


Figure 1: Map of Huong river basin (source: Yasuto Tachikawa et al., 2004)

3.1.2 Conceptual model of Huong river basin

A conceptual model of a river basin describes simply components of the basin including large rivers, branched rivers, reservoirs, dams, water factories, pump stations, residential areas ..., providing an overall picture of the relationship between these components and then initial ideas will be worked out to develop an effective monitoring plan. A conceptual model of Huong river basin is presented in Figure 2

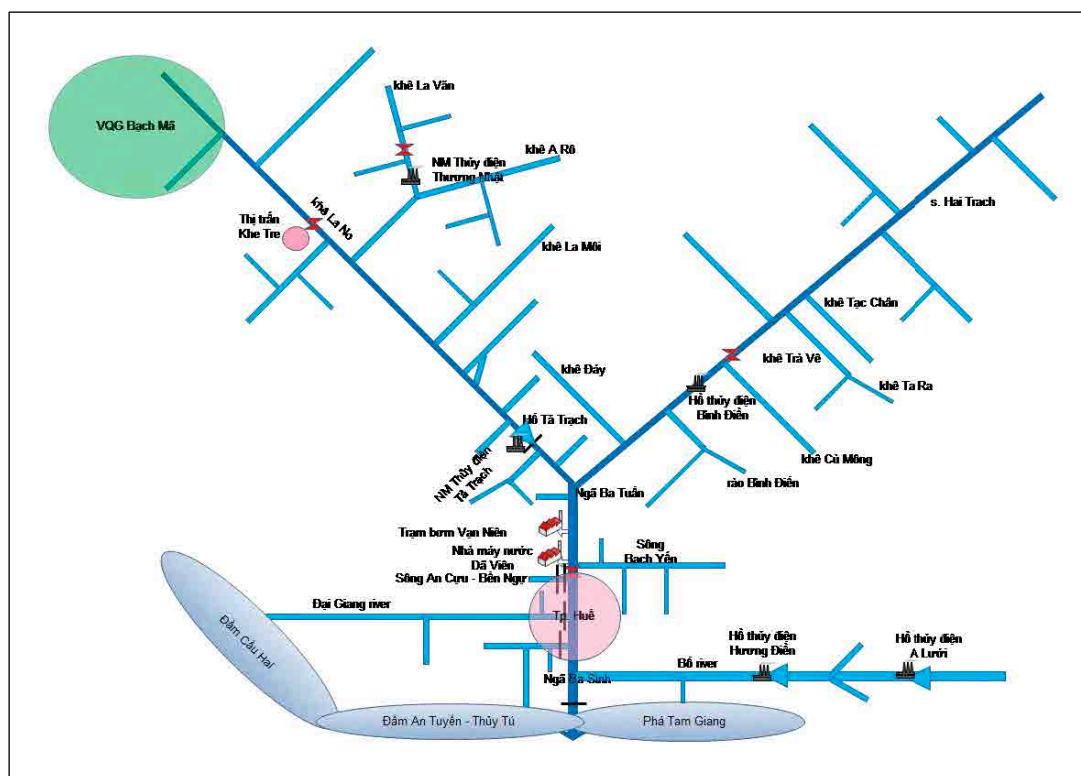


Figure 2: A concept model of Huong river basin

3.1.3 Land use classification in Thua Thien Hue province and Huong river basin

Total natural area of Thua Thien Hue province is 503,320.53 ha, 471,344.11 ha of which are exploited and put into use, representing 93.65% of natural area; unused land is 31,976.42 ha, or 6.35% of natural land. Natural land is distributed in districts, Huong Thuy town and Hue city as follows:

Table 1: Natural land distribution in Thua Thien Hue province

	Area (ha)	Percentage (%)
The whole province	503,320.53	100.00
1. Hue city	7,168.49	1.42
2. Phong Dien district	95,081.28	18.89
3. Quang Dien district	16,294.75	3.24
4. Huong Tra district	51,853.40	10.30
5. Phu Vang district	27,987.03	5.56
6. Huong Thuy town	45,602.07	9.06
7. Phu Loc district	72,092.03	14.32
8. Nam Dong district	64,777.88	12.87
9. A Luoi district	122,463.60	24.34

(Source: Statistical land report 2010, Decision 16/BC-UBND dated 02/March /2011, People's Committee of Thua Thien Hue Province)

By 2010, the land fund of Thua Thien Hue province was used as follows:

Table 2: Land use classification of Thua Thien Hue Province

No	Land category	Area (ha)	Percentage (%)
1	Agricultural land	382814.37	76.06
1.1	Agricultural land	59285.34	11.78
1.2	Forestry land	317333.87	63.05

1.3	Aquaculture land	5895.49	1.17
1.4	Other agricultural land	299.67	0.06
2	Non-agricultural land	88529.74	17.59
2.1	Residential land	17827.39	3.54
2.2	Land for special use	28680.67	5.70
2.3	Land for religious beliefs	1010.41	0.20
2.4	Cemetery land	9711.68	1.93
2.5	Rivers, streams and specially used water surface	31288.76	6.22
2.6	Other non-agricultural land	10.83	
3	Unused land	31976.42	6.35
3.1	Unused plain land	6341.41	1.26
3.2	Unused mountainous land	24916.31	4.95
3.3	Rock mountains without forest trees	718.70	0.14
Total		503320,53	100

(Source: Statistical land report 2010, Decision 16/BC-UBND dated 02/March /2011, People's Committee of Thua Thien Hue Province)

Huong river basin is located entirely in Thua Thien Hue province, covering an area of about 2830 km², or 56.2% of the provincial area. Natural forests, forest plantation and meadows account for a large area of the basin (42.7%); rice cultivation land mainly focus in Bo river basin or 10.3% of the basin area. Besides, some area is spent for perennial and short-term crop cultivation plants (5.92% of basin area). Hue city represents most of residential land of the whole province. Map of land use in Huong river basin can be seen in Figure 3.

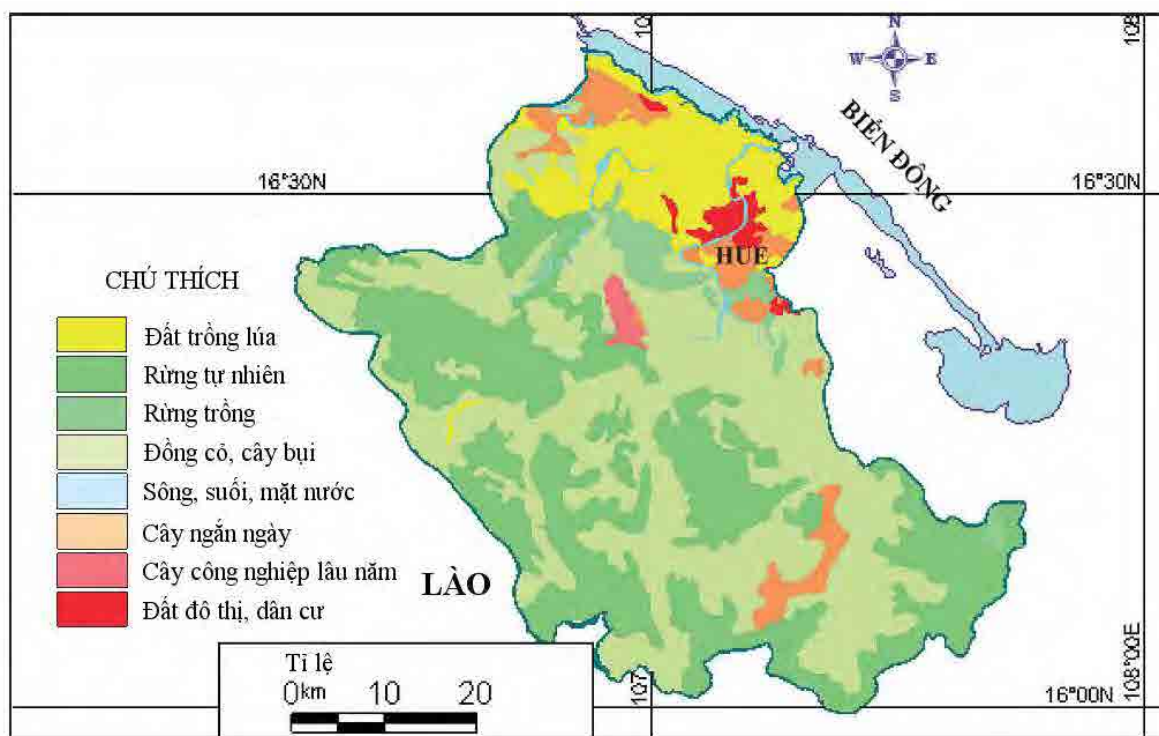


Figure 3: Map of land use in Huong river basin (source: Yasuto Tachikawa et al., 2004)

3.1.4 Population distribution

By 2010, the population in Thua Thien Hue province was 1,082,171 people (535,860 males; 546,311 females). Regarding population distribution, 467,148 people live in urban area and 615,023 people in rural area. Map of population distribution in administrative units of Thua Thien Hue province is shown in Figure 4.

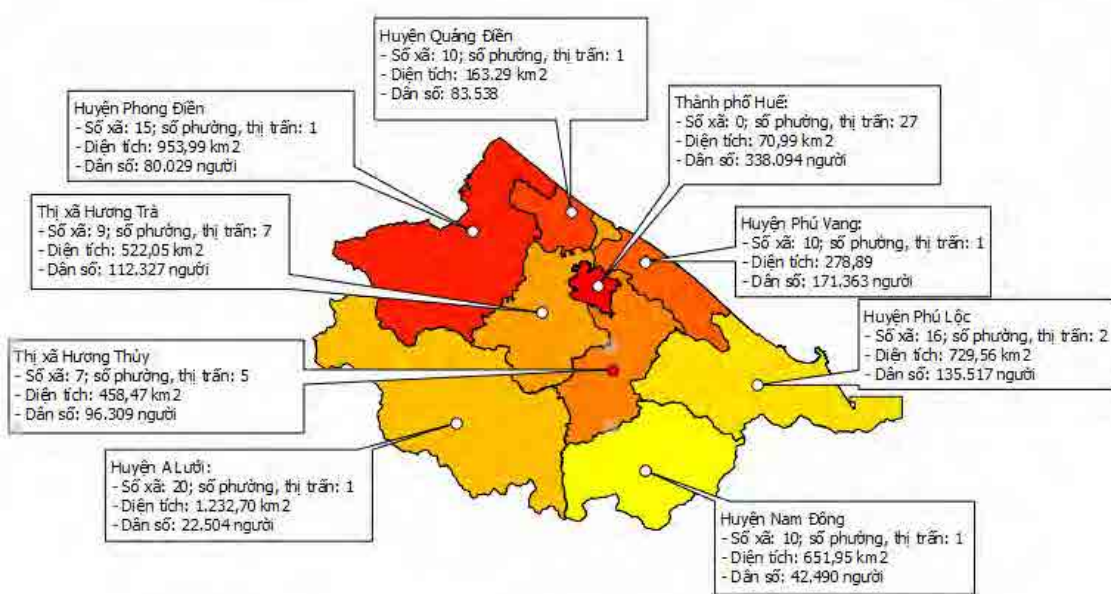


Figure 4: Population distribution in different administrative units of Thua Thien Hue province (source: Statistical data of People's Committee of Thua Thien Hue province, 2010)

3.2 Hydro-meteorological data

3.2.1 Hydro-meteorological monitoring network

Hydro-meteorological data is one of the important factors contributing to the development of a monitoring plan as rainfall and flow discharge greatly influence river water quality. When rain falls, pollutants are washed away from the ground/surface, sewer systems, cultivation fields ... into rivers, increasing contents of some pollutants. Additionally, when river water level is high, self-cleaning capacity of rivers is improved, leading to a change in river water quality. Therefore, on developing a monitoring plan, sampling and assessment of analysis results, seasonal factor of a study site and related hydro-meteorological conditions should be considered.

According to Decision No 16/2007/QĐ-TTg of the Prime Minister on approval of “*Master plan for a national network of natural resources and environment monitoring till 2020*”, it is expected that Thua Thien Hue will have a total of 3 meteorological stations, 7 hydrological stations and 24 rainfall measurement stations by 2020. A list of meteorological, hydrological and rainfall measurement stations is indicated in Appendix I. Figure 5 shows location of meteorological, hydrological and rainfall measurement stations.

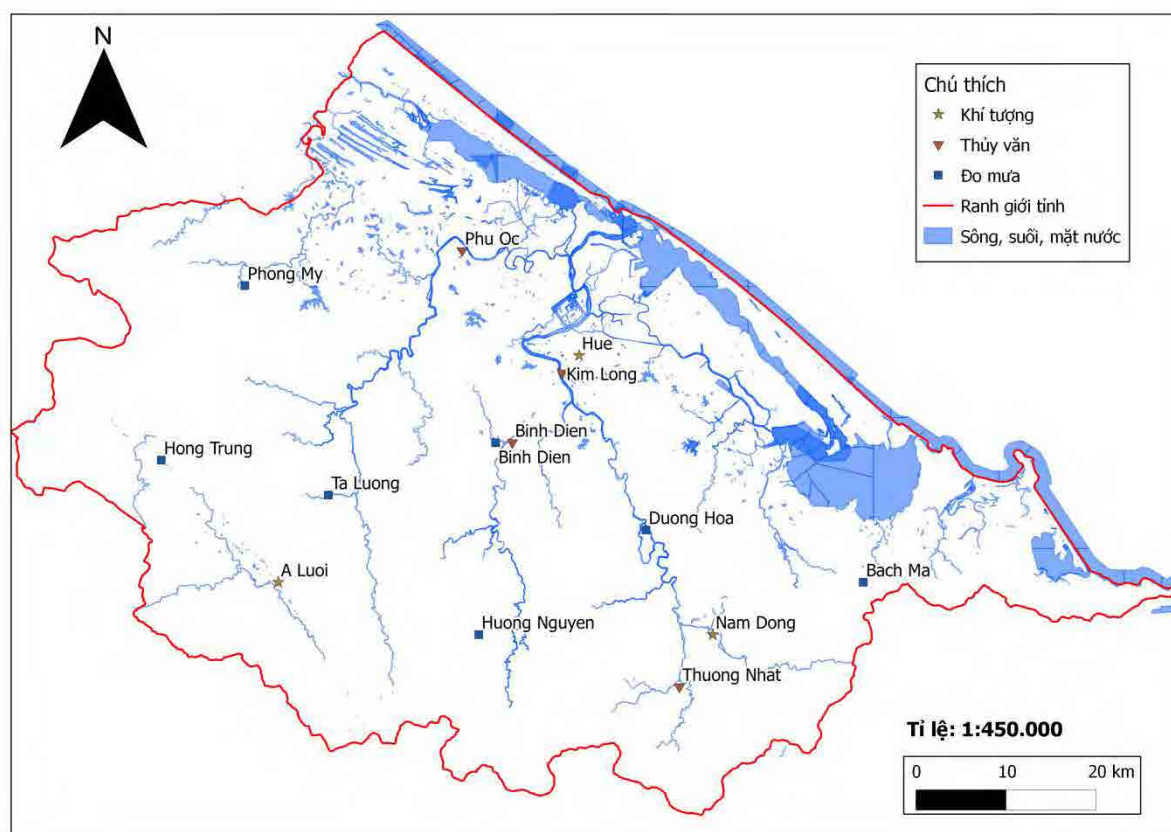


Figure 5: Location of location of meteorological, hydrological and rainfall measurement stations in Thua Thien Hue province

These meteorological, hydrological and rainfall measurement stations belong to the national network of natural resources & environment monitoring; therefore, collected data are sent to and managed by the Centre for Hydro-meteorological Documentation under MONRE. Data can be collected from Mid-Central Regional Hydro-meteorological Centre, addressed: 660 Trung Nu Vuong - Hai Chau district – Da Nang.

3.2.2 Hydro-meteorological data

3.2.2.1 Meteorological data

Below are some monitoring stations providing data trend; attention should be paid to the consideration of monitoring plan expansion.

No	Station name	Monitoring data	Monitoring period
1	Hue meteorological station	Rainfall; Evaporation; Number of sunny hours	1956 ~ to date
2	A Luoi meteorological station	Rainfall; Evaporation; Number of sunny hours	1973 ~ to date
3	Nam Dong meteorological station	Rainfall; Evaporation; Number of sunny hours	1973 ~ to date
4	Ta Luong rainfall station	Rainfall	1978 ~ 1989, 1990 ~ to date

Below is a chart of average monthly temperature and rainfall in Hue station, with data trend from 1960 to 1994, (typical for a plain region) and Nam Dong station, with data trend from 1976-2004 (typical for a mountainous region).

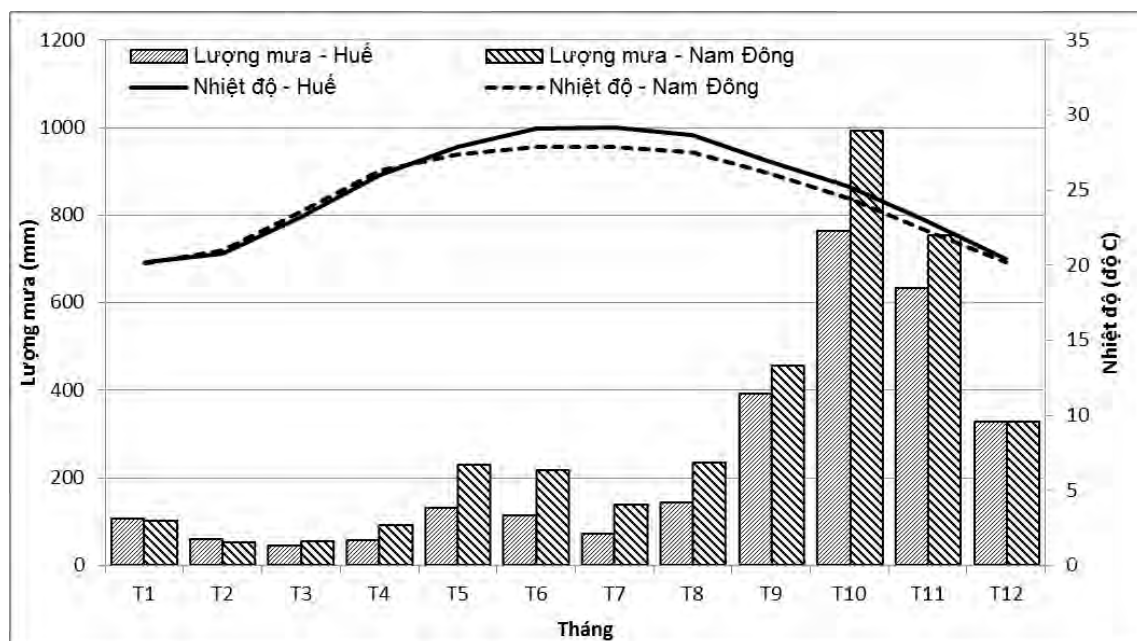


Figure 6: Average monthly temperature and rainfall in Hue station and Nam Dong station

3.2.2.2 Hydrological data

3.3 Location of water intake stations & water factories

Location of some water factories located in downstream area of Huong river is presented in Figures 8. Some information on these water factories and pump stations.

Table 3: List of water intakes and water plant in Huong river basin

No.	Plant	Location	Features	Capacity	Treatment technology
1	Van Nien water intake	Truong Da village (Vong Canh hill), Thuy Bieu commune, Hue city, 31.3km from Thuan An river mouth, 6km from Hue city by road	Grade I station, supplying water for Quang Te I, II water plants. Ideal location to supply raw water, no sea water intrusion in summer. Average depth at intake location is +4.2m.	Design capacity 120,000m ³ /day, actual current capacity 65,000m ³ /day.	
2	Quang Te I water treatment plant	Located in Quang Te hill, Thuy Xuan commune, Hue city, 3000m from Van Nien water intake, 3000m from Hue city	Natural elevation +37m to +42m. seriously degrading, operation will stop in the next few years	Total capacity 55,000m ³ /day, current operational capacity 40,000m ³ /day	Incoming water --> PAC, Cl ₂ ---> deposition ---> aquazur filter (quartz) ---> deposition --->sterilized with Cl ₂ /NaOCl
3	Quang Te II water treatment plant	Located in Quang Te hill, Thuy Xuan commune, Hue city, 2600m from Van Nien intake and 50m from Quang Te I 50m.	Natural elevation from +37,5m to +42m.	Total capacity 82,500 m ³ /day	Incoming water --> PAC, Cl ₂ ---> deposition ---> aquazur filter (quartz) ---> deposition --->sterilized by Cl ₂ /NaOCl
4	Da Vien water treatment plant	Located in Da Vien river islet, Duc water, in the city center of Hue, upstream of Bach Ho bridge. Natural elevation from +1,8m to +2,5m.	Consisting of raw water pumping station (level I), water treatment facilities and level II pumping station. Raw water intake point is 19.2km from Thuan An river mouth. Every year, water is saline from 1 to 4 months from April to August.	Current operational capacity is 12.000m ³ / day	Incoming water --> PAC, Cl ₂ ---> deposition ---> Aquazur filter (quartz) ---> GAC filter ---> sterilized by UV ---> sterilized by NaOCl
5	Tu Ha water treatment plant	Located in Tu Ha town, Huong Tra district, 17km from Hue city center to the North.	Consisting of level I raw water pumping station, treatment facilities and level II pumping station water pumped from Bo river	Capacity 12.000m ³ /day	Incoming water --> PAC, Cl ₂ ---> deposition ---> Aquazur filter (quartz) ---> GAC filter ---> sterilized with Cl ₂ /NaOCl

No.	Plant	Location	Features	Capacity	Treatment technology
6	Nam Dong water plant	Located in Khe Tre town, Nam Dong district. Supplying water for residents, agencies, industries in Khe Tre town	Consisting of one level I pumping station and one water treatment plant in elevation +72m.	Capacity 500 m ³ /day	Nước vào --> PAC ---> lắng ---> lọc Aquazur (thạch anh) ---> NaOCl

Source: website capnuochue.com.vn and huewaco.com.vn (2012)

3.4 Irrigation works in Huong river system

3.4.1 Dams at beginning of tributaries and salt intrusion prevention works

Downstream areas of Huong river see a lot of dams and sluice gates. The sluice gates connecting rivers and lagoons (Dien Truong gate, Cau Long gate, Quan gate...) play a role in salt intrusion prevention and water retention in dry season (Le Manh Hung, 2005). The most important one is Thao Long weir at the end of Huong river. In addition to its role in salt intrusion prevention and water retention, Thao Long weir contributes to controlling water level in Huong river (HCM City University of Technology, 2010). In addition, in Huong river system, dams and sluice gates in branched rivers are found namely Da dam, La Y sewer, Cua Hau dam, and Phu Cam sewer. A list of main irrigation works in Huong river system can be seen in Table 3.

Table 3: Water works in downstream area of Huong river

No	Works	Width (m)	Bottom elevation (m)	Water receiving place	Role
1	An Xuan gate	24	-2.5	Tam Giang lagoon	Salt intrusion prevention
2	Quan Cua gate	24	-2.5	Tam Giang lagoon	Salt intrusion prevention
3	Phu Cam gate	16	-2.5	South of Huong river	Salt intrusion prevention, prevention of May-rain flood
4	Da weir	200	1.48	South of Huong river	Salt intrusion prevention, prevention of May-rain flood, transportation facilitation
5	La Y gate	26	0.7	South of Huong river	Salt intrusion prevention, prevention of May-rain flood
6	Quan gate	24	-1.5	Cau Hai lagoon	Salt intrusion prevention
7	Thao Long dam	502	-2.5	Thuan An	Salt intrusion prevention
8	Dien Hong gate	24	-2.5	Thuan An	Salt intrusion prevention
9	Cau Long gate	24	-2.5	Thuan An	Salt intrusion prevention

3.4.2 Reservoirs in Huong river system

There are three reservoirs that have regulated and will regulate water in upstream area of Huong river, including Ta Trach reservoir work in Ta Trach river, Binh Dien hydro-power works in Huu Trach river and Huong Dien hydro-power works in Bo river. Additionally, A Luoi hydro-power plant is found in mountainous district of A Luoi in upstream area of Bo river. After being used for water generation in A Luoi hydro-power plant, the water will be transferred to Bo river and flow into Huong Dien reservoir (terrace-type power generation); consequently, A Luoi hydro-power works does not

have much impact on water regulation for Huong river in downstream area. The list of reservoirs in Huong river system is presented in Table 4.

Table 4: Reservoirs in Huong river system

No	Name	Functions	Main specifications	Status
1	Ta Trach reservoir (in Ta Trach river)	<ul style="list-style-type: none"> - Flood prevention - Maintain environmental flow at 25m³/s in dry seasons - Supply water for domestic and industrial uses Q = 2m³/s - Power generation capacity N = 19 MW - Water for 34.782 ha of cultivated land 	<ul style="list-style-type: none"> - Basin area: 717 km² - Normal WL: + 45,0m. - WL before flood: + 25,0m - Dead water level: + 23,0m - Total storage: 646 x 10⁶m³ - Flood prevention storage with P = 0,1%: 556,2 x 10⁶m³ - Flood prevention storage with P = 0,5%: 435,9 x 10⁶m³ - Dead storage: 73,4 x 10⁶m³ - Main dam: Elevation +55m, height 60m, length 1.187 m, width 10 m 	Đang xây dựng, dự kiến hoàn thành năm 2013 và đưa vào sử dụng năm 2014 (Thông tin từ Chi cục Thủy Lợi, Sở NN&PTNT TT-Huế).
2	Binh Dien (Huu Trach reservoir)	<ul style="list-style-type: none"> - Flood prevention for Hue city, lower than flood level from 1.1m to 1.2m in flood season. - Power generation capacity 44MW - Tưới cho 11.000 đất nông nghiệp - Domestic water supply 1.1 m³/s. 	<ul style="list-style-type: none"> - Basin area: 515 km² - Normal WL: 85 m. - Total storage capacity 423 mil m³. - Main dam is roll compact concrete, 331.6m long, crest level is 83.5m. - Spillway has 5 gates 	Came into operation since 2009
3	Huong Dien (Bo river)	<ul style="list-style-type: none"> - Flood prevention for downstream - Power generation capacity 81MW - Maintain environmental flow 	<ul style="list-style-type: none"> - Total storage capacity 800x10⁶m³ 	Came into operation since 2010

Source: Viet Nam's Committee of Large Dams

Location of sewers, dams and reservoirs in Huong river system is illustrated in Figure 7.

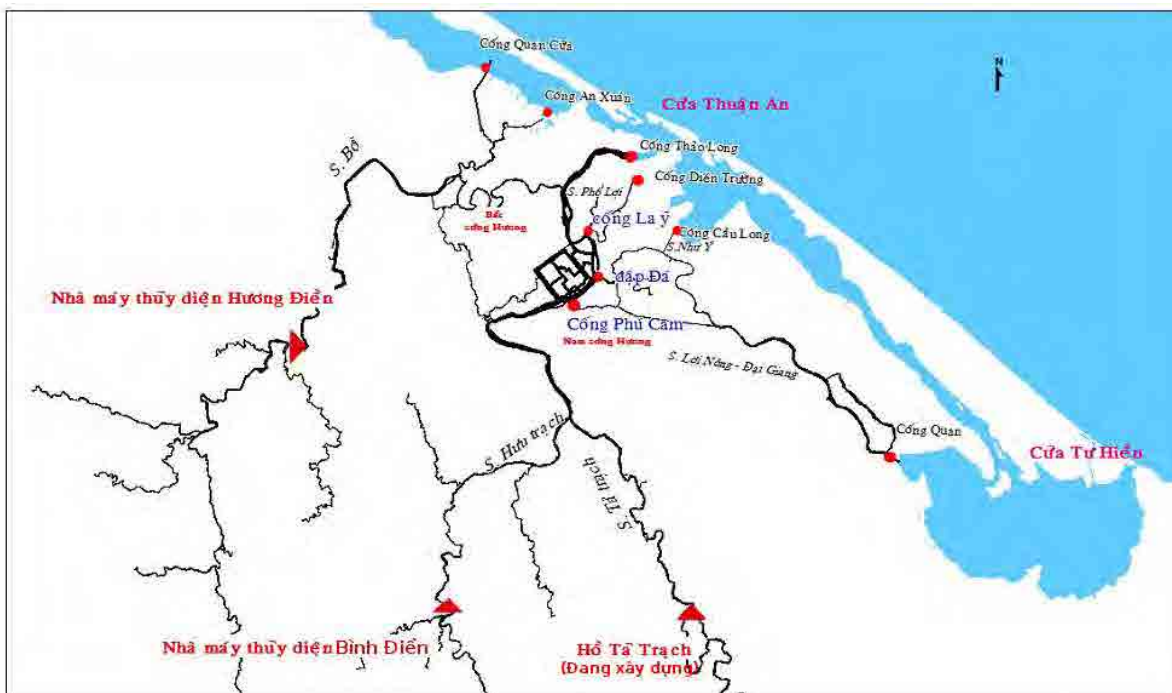


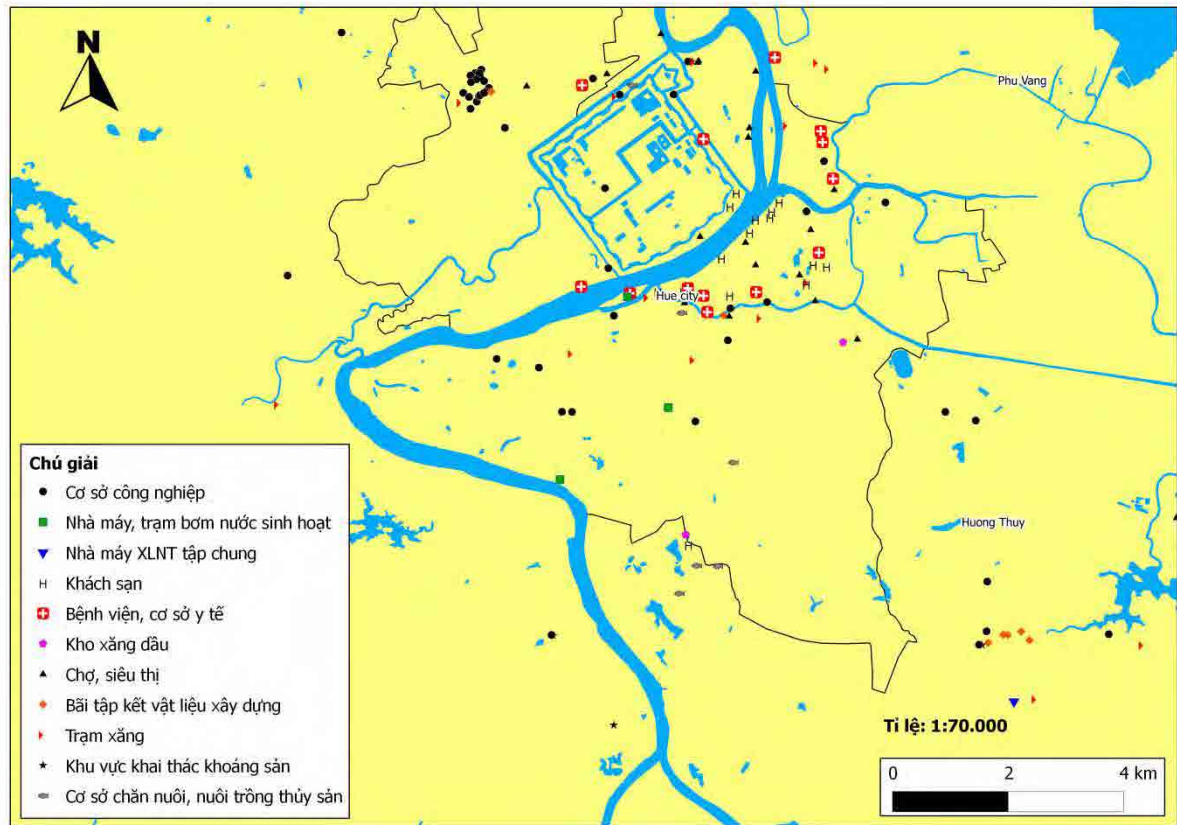
Figure 7: Location of sewers, dams and reservoirs in Huong river system (Source: Nguyen Ngoc Minh, 2010)

3.5 Location of potential pollution sources and sensitive receivers

Potential pollution sources include hospitals, services and bussiness entities (restaurants, hotels), markets, petroleum storage and especially industrial entities, husbandry entities ... During the survey in November 2011, EPA of Thua Thien - Hue Province carried out the collection of data on geographical coordinates of potential pollution entities. As this survey only covers the collection of data on geographical coordinates, pollution loads as well as specific pollutants were not investigated; as a result, in this document, these entities are considered to be “potential pollution sources”.

Sensitive receivers are defined as raw water pumping stations, domestic water supply factories, entertainment destinations with water surface contact or utilization (bathing beach, parks ...). According to the staff of EPA of Thua Thien Hue Province, in Huong river basin, no entertainment destinations with water surface contact or utilization are found; therefore, sensitive receivers in Huong river basin include only pumping stations and water factories.

As most of potential pollution sources are concentrated in Huong river downstream area – the section running through Hue city – The below Figures 8 only focuses on this area. The map of potential pollution sources and sensitive receivers in the whole Thua Thien Hue province is enclosed in Appendix II.



Figures 8: Location of potential pollution sources and sensitive receivers

The above survey shows that industrial wastewater exerts little impact on Huong river downstream area due to a limited number of industrial entities and their far distance from the river. Main wastewater source comes from hospitals, service and bussiness entities such as restaurants and hotels, some local markets and especially domestic wastewater from residential areas along the two river banks. The finding is consistent with problems of water quality of Huong river generalized in Table 1.

CHAPTER 4.MONITORING PLAN

4.1 Monitoring network

Based on the information collected from Chapter 3, the monitoring plan is designed as follows:

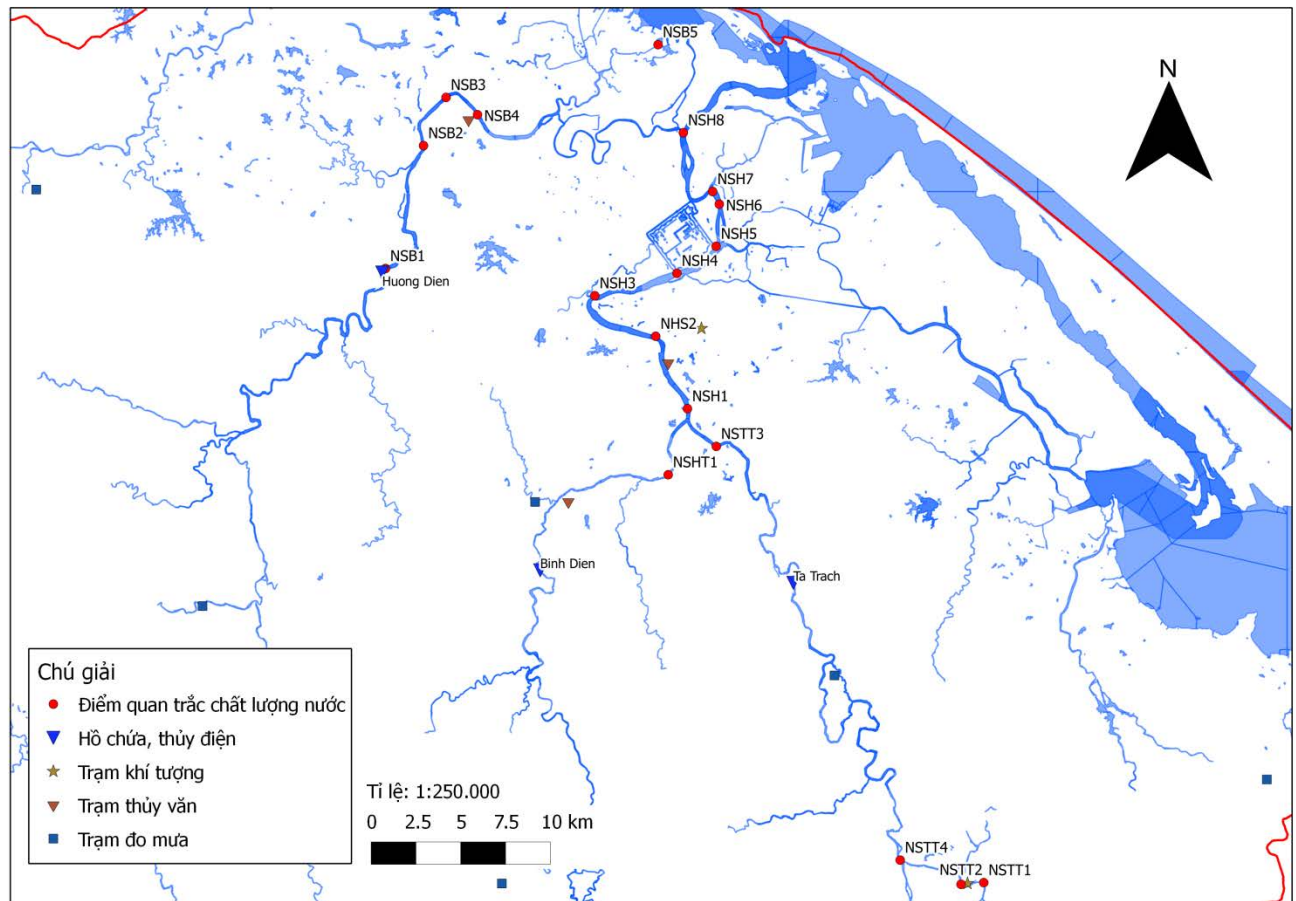


Figure 9: Map of water quality monitoring points in Huong river system

Detailed description of monitoring points

Table 5: Description of water quality monitoring points in Huong river system

River	No	Station code	Sampling site	Objectives	Sampling way ²
1. Huong	1	N _{SH1}	X: 107.5763336; Y: 16.3949115. Tuan bridge	To measure water quality at the point after two rivers of Ta Trach and Huu Trach merge into Huong river	Composite sampling (Lấy mẫu tổ hợp): 1 sample is taken near the left river bank, 1 sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample.
	2	N _{SH2}	X: 107.560422; Y: 16.42957734. Van Nien water plant	To measure raw water quality for water treatment plant	Sampling about 20m from the right bank
	3	N _{SH3}	X: 107.5299152; Y: 16.44903933 Xuoc Du bridge (Huong Ho commune/Huong Tra)	To measure water quality of Bach Yen river before it flows into Huong river	Composite sampling: 1 sample is taken near the left river bank, 1 sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample.
	4	NSH4	X: 107.5710828; Y: 16.45979645. New Bach Ho bridge	To monitor quality of inflow water for water treatment plant	Composite sampling: 1 sample is taken near the left river bank, 1 sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample
	5	N _{SH5}	X: 107.5906819; Y: 16.4727593 Dong Ba market	To measure water affected by the market. The measurement station is near the end of the market (Trạm đo ở phía dưới chợ). The market is in the list of serious pollution entities in 2004 according to Decision 64, and in 2009, it is removed from the market.	Sampling about 20 m from the left bank of Huong river
	6	N _{SH6}	X: 107.592290; Y: 16.492966.	To measure water quality due to the impact of the market,	Composite sampling: 1 sample is

² Sampling procedures: TCVN 5992:1995 “Water quality – Sampling – Guideline for sampling techniques” and TCVN 5996:1995 “Water quality – Sampling – Guideline for sampling in river and streams”

River	No	Station code	Sampling site	Objectives	Sampling way ²
			Dinh market bridge (Phu Thuong commune, Phu Vang – Phu Hau, Hue city)	Hue beer factory and residential areas of the two river banks.	taken near the left river bank, 1 sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample
	7	N _{SH7}	X: 107.5889447; Y: 16.49903453 La Y dam (Phu Mau commune-Phu Thuong, Phu Vang), about 20m from the bank	Close to the point NSH6 (800m). Monitoring objectives should be re-considered.	Sampling about 20 m from the right bank of Huong river
	8	N _{SH8}	Sinh confluence (Huong Vinh-Huong Phong, Huong Tra),	Bo river water flows into Huong river. Sampling location has not yet been clearly identified; presently, land use status has been changed.	Sampling about 20 m from the left bank of Huong river
2. Bo	9	N _{SB1}	Bottom of Huong Dien hydro-power reservoir (Huong Van commune, Huong Tra)	Sampling location has not yet been clearly identified. If water sample is taken in the reservoir, this place should be considered as a sampling point for water quality monitoring of Huong Dien hydro-power reservoir .	
	10	N _{SB2}	X: 107.4440747; Y: 16.52107081 Hien Si bridge (joining Thong Nhat railway, Huong Van commune, Huong Tra – Phong Son commune, Phong Dien)	The first monitoring point from Huong Dien reservoir. Checking water quality in the downstream area of Bo river before the water runs through residential area (Tu Ha township)	Composite sampling: 1 sample is taken near the left river bank, 1 sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample
	11	N _{SB3}	X: 107.4553761; Y: 16.5442081 An Lo bridge (joining National Highway 1 A, Tu Ha township, Huong Tra, in the upstream of Tu Ha water factory)	About 3.2km from N _{SB2} . Monitoring objectives have not yet been clearly identified.	Composite sampling: 1 sample is taken near the left river bank, 1 sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample
	12	N _{SB4}	X: 107.4774699; Y: 16.52635456 Tu Ha water supply station (Tu Ha township, Huong Tra)	To monitor quality of raw water supplied for water treatment plant	Sampling 20m from the right river bank
	13	N _{SB5}	X: 107.5616035; Y: 16.56951659 An Xuan sewer gate, sampling at the middle of	New point. To monitor Bo river water quality before the water runs into Tam Giang lagoon.	Composite sampling: 1 sample is taken near the left river bank, 1

River	No	Station code	Sampling site	Objectives	Sampling way ²
			the gate		sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample
3. Ta Trach	14	N _{STT1}	X: 107.7249675; Y: 16.16639085 Upstream of Khe Tre bridge, about 5m from the river bank	To check water quality before the river water runs through densely populated Khe Tre area. Being close to Nam Dong water factory. [accurate coordinates have not yet been clearly identified]	Sampling 20 m from the right bank of the river
	15	N _{STT2}	X: 107.7190023; Y: 16.16663992 Khe Tre bridge, Khe Tre market area, 5m from the river bank	To check water quality after the river runs through Khe Tre.	Composite sampling: 1 sample is taken near the left river bank, 1 sample in the middle of the bridge and 1 sample near the right bank; the three sampels are mixed to get one new sample
	16	N _{STT3}	Upstream of Tuan confluence, Ta Trach river	Unclear sampling location that should be re-confirmed	Sampling 10 m from the right bank of the river
	17	N _{STT4}	X: 107.682061; Y: 16.179423. Confluence downstream of Khe Tre township	Confluence of the two rivers, to check water quality before the water runs into Ta Trach reservoir	Sampling 20 m from the right bank of the river
4. Huu Trach	18	N _{SHT1}	Upstream of Tuan confluence, Huu Trach river		

4.2 Monitoring parameters

Presently, water quality monitoring plan in Huong river covers the analysis of 12 parameters and uses Vietnamese technical regulations on surface water quality QCVN 08:2008 for comparison. Specific parameters, reasons for selection of these parameters and limit value stipulated in QCVN 08:2008 can be seen in the table below:

Table 6: Parameters for assessment of Huong river water quality

No	Parameter	Unit	Reason for selection	Limit values in QCVN 08:2008			
				A1	A2	B1	B2
1	pH	-	Circular 29/calculation of WQI	6-8.5	6-8.5	5.5-9	5.5-9
2	DO	mg/l	Circular 29/calculation of WQI	≥ 6	≥ 5	≥ 4	≥ 2
3	TSS	mg/l	Circular 29/calculation of WQI	20	30	50	100
4	COD	mg/l	Circular 29/calculation of WQI	10	15	30	50
5	BOD ₅	mg/l	Circular 29/calculation of WQI	4	6	15	25
6	N-NH ₄ ⁺	mg/l	Circular 29/calculation of WQI	0.1	0.2	0.5	1
7	N-NO ₂	mg/l	Determining pollution level of nutrients	0.01	0.02	0.04	0.05
8	N-NO ₃	mg/l	Determining pollution level of nutrients	2	5	10	15
9	P-PO ₄	mg/l	Circular 29/calculation of WQI	0.1	0.2	0.3	0.5
10	Oil&grease	mg/l	Determining oil spill level on surface water	0.01	0.02	0.1	0.3
11	Phenol	mg/l	Determining organic pollution level	0.005	0.005	0.01	0.02
12	Coliform	mg/l	Circular 29/calculation of WQI	2500	5000	7500	10000

4.3 Monitoring time and frequency

4.3.1 Monitoring frequency

- Monitoring frequency is 4 times/year (once a quarter)

4.3.2 Time boundary

- The monitoring plan lasts for one year from 15/January/2013 to 15/January/2014, including such activities as 4 times of sampling, analysis, result evaluation and report preparation (6 monthly report and yearly report)
- Sampling time from 8:30 a.m to 16:30 p.m applied to all samples.
- If it heavily rains on the sampling day (as planned), the sampling will be done on the next day (without rain).

4.3.3 Time frame of the monitoring plan

	Tháng Một	Tháng Hai	Tháng Ba	Tháng Tư	Tháng Năm	Tháng Sáu	Tháng Bảy	Tháng Tám	Tháng Chín	Tháng Mười	Tháng Mười Một	Tháng Mười Hai
Work/time												
Sampling												
Analysis												
Reporting												
Holidays/Tet												

Some notes regarding the time for implementing the monitoring plan

- Tet holiday: Sample collection for BOD analysis should be avoided before Tet holiday.
- Sampling: sampling in all locations should not be conducted on one day; therefore, there should be different groups in charge of sampling; each group is responsible for some sampling points.
- The time from sampling to analysis results obtaining: 15 days
- In case of hiring consultants (sub-contractors) for result analysis, it is necessary to request them to provide the results right after completion of all the analysis.

4.4 Sample preservation method

Table 7: Method of sample preservation

No	Parameter	Container	Preservation method	Volume (mL)	Preservation time (optimal)	Preservation time (maximum)
1	DO	Glass bottle	-	1000	Right after sampling	4 hours
2	pH	Polyethylene bottle	below temperature when sampling	1000	Right after sampling	6 hours
3	TSS	Polyethylene bottle	4 ⁰ C	1000	4 hours	48 hours
4	TDS	Polyethylene bottle	4 ⁰ C	1000	4 hours	24 hours
5	BOD	Polyethylene bottle	4 ⁰ C	1000	4 hours	24 hours
6	COD	Polyethylene bottle	4 ⁰ C	1000	-	5 days
7	Oil & grease	Glass bottle	4 ⁰ C	1000	-	24 hours
8	Nitrate (NO ₃ ⁻)	Polyethylene bottle	4 ⁰ C	1000	-	24 hours
9	Nitrite (NO ₂ ⁻)	Polyethylene bottle	4 ⁰ C	1000	-	24 hours
10	Phenols	Glass bottle	4 ⁰ C	1000	-	24 hours

4.5 Analytical method

Table 8: Analytical methods

No	Parameter	Instrument	Analytical method	Analytical agency
1	pH	HORIBA U52	Quick measure in the field	Station
2	Conductivity	HORIBA U52	Quick measure in the field	Station
3	DO	HORIBA U52	Quick measure in the field	Station
4	BOD	YSI DO meter, BOD Refrigerated Thermostat (FOC 225E)	APHA-5210-B; TCVN 6001-1:2008	External lab
5	COD	Digester, UV-Vis	TCVN 6491:1999; APHA-5220-C/D	
6	TSS	Glass fiber filter paper, filter funnel, vacuum sucker, oven, dehumidifier, technical scale	TCVN 6625:2000	
7	TDS	Stove, dehumidifier, technical scale, vacuum filter	TCVN 6053:1995	
8	NH ₄ ⁺ -N	Stove, UV-Vis	TCVN 6179-1:1996	
9	NO ₃ ⁻ -N	Bain-marie boiler, UV-Vis	TCVN 6180:1996	
10	PO ₄ ³⁻ -P	Filer, UV-Vis	TCVN 6202:2008	

No	Parameter	Instrument	Analytical method	Analytical agency
11	Phenol	Distiller , UV-Vis	TCVN 6216:1996; ISO 6439:1990	
12	Oil & grease	Extraction funnel, oven	US-EPA 1664	

4.6 Actual constraints

Difficulties in getting access to sampling sites:

- + A Luoi area: remote area, not easily accessible and therefore, no sampling stations are set up here.
- + Phong Dien area: it can be accessed by car to the nearby place; then, the sampling group has to walk to the sampling station.
- + No problems in getting access to sea ports.
- + In order to access the National Park, it is necessary to acquire a permit; but there is no difficulty in obtaining the permit. During the plan making, it is necessary to clearly point out the date of asking for the permission, and sampling places.
- + Points, areas for the military in Hue. Asking for permission to come into these areas is required. Information on the sampling is requested.
- + In sensitive areas, asking for permission is required if necessary.

Travelling time:

- + Travelling to all the sampling sites and returning on the same day.

Laboratory:

- + The analysis center is selected because a number of parameters can be analyzed here. If there are some problems with the centre, which unit can be replaceable?

4.7 Budget for the monitoring plan

Detailed costs for the implementation of the monitoring plan is estimated.

CHAPTER 5. METHOD OF DATA ANALYSIS

5.1 Applied action level

So far, no official instruction documents regulating water use purposes for each river section in Huong river system have been found. Water treatment factories such as Da Vien (Huong river), Tu Ha (Bo river), Quang Te (water supplied from Van Nien pumping station in Huong river) experience advanced treatment technology; thus, inflow water is only required to meet A2 column. Besides, according to the main water use purposes and land use status on the two river banks, monitoring plan making group suggests the applied action level (applied standard) as follows:

No	River section	Use purposes	Applied standard
1	Ta Trach river and Huu Trach river from upstream to Tuan confluence	Agricultural irrigation, waterway transportation	QCVN 08:2008/B1
2	Huong river from Van Nien pumping station to Da Vien water factory	Pumping of raw water for the water factory	QCVN 08:2008/A2
4	Huong river from Da Vien water factory to Cho Dinh bridge	Transportation, tourism	QCVN 08:2008/B1
4	Huong river from Cho Dinh bridge to Thao Long dam	Waterway transportation	QCVN 08:2008/B2
5	Bo river from behind Huong Dien hydro-power dam to An Lo bridge	Irrigation, waterway transportation	QCVN 08:2008/B1
6	Bo river from An Lo bridge to Tu Ha water factory	Pumping of raw water for the water factory	QCVN 08:2008/A2
7	Bo river from Tu Ha water factory to An Xuan sewer	Irrigation, waterway transportation	QCVN 08:2008/B1

Water quality is considered to “meet the requirements” when all monitoring parameters meet the above standards. In contrast, if any parameter exceeds the standard, that parameter is considered not to meet the requirement corresponding to water use purposes of that river section.

5.2 Summarised results of each parameter

With the above water use requirements, the highest standard applied is A2 column of QCVN 08:2008; so, selected methods of analysis have to meet the values of parameters in level A2

No	Parameter	Comparison level	Action level				Required detection limit	Actual detection limit	Method of analysis
			A1	A2	B1	B2			
1	pH	Low - high	6.0-8.5	6.0-8.5	5.5-9.0	5.5-9.0	-	0-14	On-site measurement
2	Conductivity	Highest	-	-	-	-	-	0-100	On-site measurement
3	DO	Lowest	6.0	5.0	4.0	2.0	1.0	0	On-site measurement
4	BOD	Highest	4.0	6	15	25	1.2	2.0 3.0	APHA-5210-B; TCVN 6001-1:2008
5	COD	Highest	10	15	30	50	3.0	30 3.0	TCVN 6491:1999 APHA-5220-C/D
6	TSS	Highest	20	30	50	100	6	10	TCVN 6625:2000
7	TDS	Highest	-	-	-	-	-	10	TCVN 6053-1995

No	Parameter	Comparison level	Action level				Required detection limit	Actual detection limit	Method of analysis
			A1	A2	B1	B2			
8	NH ₄ ⁺ -N	Highest	0.1	0.2	0.5	1.0	0.04	0.008	TCVN 6179-1:1996
9	NO ₃ ⁻ -N	Highest	2.0	5.0	10	15	1.0	0.013	TCVN 6180:1996
10	PO ₄ ³⁻ -P	Highest	0.1	0.2	0.3	0.5	0.4		TCVN 6202:2008
11	Phenol	Highest	0.005	0.005	0.01	0.02	0.001	0.01	TCVN 6216:1996;
									ISO 6439:1990
12	Oil&grease	Highest	0.01	0.2	0.4	0.5	0.04	1.4	US-EPA 1664

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APPENDICES

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APPENDIX I: LIST OF HYDROLOGICAL AND METEOROLOGICAL STATIONS

TT	Loại trạm	Tên trạm	Địa điểm	Tọa độ địa lý (UTM)	
				X	Y
1	Khí tượng	Huế	Xã Thủy Bằng, huyện Hương Thủy	107.5833	16.4333
2	Khí tượng	Nam Đông	Xã Thượng Lộ, huyện Nam Đông	107.7166	16.1666
3	Khí tượng	A Lưới	Xã Hồng Thượng, huyện A Lưới	107.2833	16.2166
4	Thủy văn	Phú Ốc	TT Tứ Hạ, huyện Hương Trà	107.4666	16.5333
5	Thủy văn	Bình Điền	Xã Bình Điền, huyện Hương Trà	107.5166	16.3500
6	Thủy văn	Kim Long	Phường Phùng Đức, TP. Huế	107.5666	16.4166
7	Đo mưa	Phong Mỹ	Xã Phong Mỹ, huyện Phong Điền	107.2500	16.5000
8	Đo mưa	Hồng Trung	Xã Hồng Trung, huyện A Lưới	107.1666	16.3333
9	Đo mưa	Bình Điền	Xã Bình Điền, huyện Hương Trà	107.5000	16.3500
10	Đo mưa	Tà Lường	Xã Hồng Hà, huyện A Lưới	107.3333	16.3333
11	Đo mưa	Hương Nguyên	Xã Hương Nguyên, huyện A Lưới	107.4833	16.1666
12	Đo mưa	Hồng Trung	Xã Hồng Trung, huyện A Lưới	107.1666	16.3333
13	Đo mưa	Dương Hóa	Xã Dương Hóa, huyện Hương Thủy	107.8666	16.2166

APPENDIX II: MAP OF POTENTIAL POLLUTION SOURCES AND SENSITIVE RECEIVERS
IN TT-HUE PROVINCE

