Initial Environmental Examination

Project Number: 41456-033
June 2012

MFF 0054-VIE: Water Sector Investment Program – Tranche 2

Thua Thien Hue Province Water Supply Project Feasibility Study Report

Asian Development Bank TA 7089-VIE

ANNEXE C

INITIAL ENVIRONMENTAL EXAMINATION (Updated for PFR2 Investment only)

June 2012

CONTENTS

ABBREVIATIONS

ADB	Asian Development Bank
AP	Affected person
DARD	Department of Agriculture and Rural Development (Provincial)
DONRE	Department of Natural Resources and Environment (Provincial)
DOPH	Department of Public Health (Provincial)
EA	Executing Agency
EMP	Environmental Management Plan
EMU	Environment Monitoring Unit
FS	Feasibility Study
GIS	Geographic Information Systems
HUEWACO	Hue Water Corporation
IEE	Initial Environmental Examination
ISO	International Standards Organization
MONRE	Ministry of Natural Resources and Environment
NGO	Non-Governmental Organization
NP	National Park
OHSAS	Occupational Health and Safety Management System
PPTA	Project Preparatory Technical Assistance
QCVN	Vietnamese Standard
REA	Rapid Environmental Assessment
RAP	Resettlement Action Plan
SEC	Senior Environmental Consultant
TA	Technical Assistance
TCVN	Vietnamese Standard
TOR	Terms of reference
TTH	Thua Thien Hue
USD	US Dollar
VND	Vietnamese Dong
WHO	World Health Organization
WTP	(drinking) Water Treatment Plant
WWTP	Wastewater Treatment Plant

SUMMARY INITIAL ENVIRONMENTAL EXAMINATION

A. Introduction

The overall objective of this Project Preparatory Technical Assistance is to prepare for ADB financing of the proposed Thua Thien Hue Water Supply Project. Under the second tranche (PFR2) of the multitranche financing facility (MFF), Water Sector Investment Program (MFF0054-VIE), the project was screened and classified as an Environmental Category B project which requires an Initial Environmental Evaluation (IEE). **Paragraphes in italics reflect future investments that could be financed under a subsequent tranche of the MFF0054-VIE after due process by ADB and the Government of Viet Nam. Those paragrahes allow a better understanding of the overall project Hue water supply to be implemented over 10 years**

The objectives of the IEE are, according to the ADB's Safeguard Policy Statement (2009):

- to identify potential direct, indirect, cumulative and induced environmental impacts on and risks to physical, biological, socioeconomic, and physical cultural resources and determine their significance and scope,
- to examine alternatives to the project's location, design, technology, and components that would avoid, and, if avoidance is not possible, minimize adverse environmental impacts and risks
- to prepare an environmental management plan (EMP) that will include the proposed mitigation measures, environmental monitoring and reporting requirements, emergency response procedures, related institutional or organizational arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators.

In accordance to these requirements, this report will be a management tool aiming at a better integration of the project to its biophysical and human environment.

B. Description of the Project

The present project covers the entire Thua Thien Hue (TTH) Province, located in Central Vietnam. The Province territory covers an area of 5,051 km^2, delimited to the North by the Quang Tri Province, to the South by the Da Nang City, to the East by the Pacific Ocean and to the West by the Cambodian border.

Summarily, the Project provides, from 2011 to 2016, for:

PFR2 (2012 – 2015)

- Construction of one new water treatment plants (WTP) at Phong Dien
- Off-take pumping stations: Phong Dien, Loc Bon
- Construction of new booster pumping stations
- Laying nearly 418 km of pipes for transmission and distribution network (diameter from 50 to 1200 mm).

Subsequent Tranches (2015 – 2020)

- *Construction of seven new water treatment plants (WTP) and five new off-take pumping stations. These include :*

  Water treatment plants: Dien Mon, Quang Te 3, Loc Bon, Loc An, Loc Tri, Loc Binh, Thuong Long

  Off-take pumping stations: Loc An, Thuong Long, Dien Mon

- *Closure of three existing WTPs. These include : Quang Te 1, Da Vien, Vinh Hien*
- *Capacity upgrade of four existing WTP, of which three with surface extension. These include : Tu Ha (surface extension and capacity upgrade from 12,000 m3/day to 32,000 m3/day), Binh Dien (surface extension and capacity upgrade from 500 m3/day to 1,000 m3/day), Chan May (capacity upgrade from 6,000 m3/day to 8,000 m3/day), A Lưới (surface extension and capacity upgrade from 2,000 m3/day to 4,000 m3/day)*
- *Capacity upgrade and surface extension of Van Nien raw water pumping station, the construction of water museum at Van Nien*
- *Construction of new booster pumping stations*
- *Laying nearly 657 km of pipes for transmission and distribution network (diameter from 50 to 1200 mm).*

More details, especially those regarding the description of treatment plants, size and location of the distribution network on the project components are given in the main Feasibility Study report.

With respect to environmental assessment, the Project can be divided into a total of eleven “impacting” subprojects distributed between tranches, as follows:

Under PFR2 (2012 – 2015): Phong Dien subproject, Quang Te subproject (including Hue City and nearby areas), Tu Ha subproject, Loc Bon subproject.

Under Subsequent Tranches (2015 – 2020): Hoa Binh Chuong subproject, Quang Te subproject (including Hue City and nearby areas), Bin Dien subproject, Loc An subproject, Loc Tri subproject, Chan May subproject, Nam Dong subproject and A Luoi subproject.

C. Description of the Environment

Physical environment

Thua Thien Hue Province has a monsoon tropical climate showing two marked seasons: the dry season from January to August and the rainy season from September to December. Most often, October and November together account for more than 50% of the total annual rainfall. A small rainy season always occurs in April and May, especially in the highlands.

The average annual rainfall in Hue has been around 3400 mm over the five last year but the western and southern parts of the Province experience an even rainier climate: 4450 mm/year in Nam Dong and 4050 mm/year in A Luoi. The annual rainfall seems to have increased in the recent years, as observed in many tropical countries.

Over the five last years, the average temperature has been 24.7 °C in Hue, 24.5 °C in Nam Dong and 21,7 °C in A Luoi. In Hue, the average temperature is around 29 °C in May, June and July and around 20 °C in December - January. The temperatures are logically cooler in the mountainous areas: respectively around 25°C and 17°C in A Luoi for the same months.

In Hue, the prevailing winds are North-West from September to April, South and South-West from May to August. The frequency of calm winds is rather high: 38% in Hue, 26% in Nam Dong and 40% in A Luoi. In Hue and Nam Dong, most of the winds are below 3m/s but in A Luoi, winds over 3m/s are the most frequent from May to August.

Due to its geographical location, the TTH Province is often hit by tropical storms and cyclones. During the last serious cyclone (Eve) in November 1999, 352 people were drowned and 25,056 houses were washed away.

Four main morphological situations can be observed in the TTH Province:

- mountainous and hilly uplands, which are found to the west, along the Laotian border and to the south along the limit of Da Nang Province. The western

mountainous area is a part of the Truong Son Mountain Range with many high peaks such as Dong Ngai peak at 1,774m and Dong Pho peak at 1,346m.

- river plains, dominated by the 500km^2-wide plain of Huong River. This plain shows very gentle slopes. The elevations are comprised between 10 and (-)1.5 m. Most of the plain is made of hollow areas occupied by rice fields.
- coastal lowlands mainly occupied by the very large Tam Giang-Cau Hai lagoon complex stretching over 68 km, i.e. almost all the length of the coast of TTH Province, parallel with the seashore. All big rivers in the area pour into Tam Giang- Cau Hai Lagoon, which opens to the East Sea by two channels
- seashore, which is mostly sandy and strait, apart from rocky outcrops of Bach Ma Range in the south-eastern end of the Province coast.

Groundwater resources are mostly exploited in the coastal plain area. In the vicinity of seashore, salt intrusion may occur and render water quality unsuitable for drinking water production. The only groundwater abstraction site for drinking water production is at Phu Bai where analysis indicates an organic contamination which is difficult to explain. In the mountainous areas, groundwater is abstracted by rural communities by means of 5 to 10 m deep boreholes.

The main river of the TTH Province is the Huong River, the catchment basin of which covers 2,830 km^2 that is 55% of the Province surface. The Huong River originates from the junction of two streams: Ta Trach River and Huu Trach River, which join around 15 km upstream of Hue City and 40 km upstream of the river mouth. In its lower reaches the Huong River receives the Bo River, the basin of which covers 938 km^2. Other main rivers are the O Lau River (to the north-west) and the Sap River (to the south).

The Water Treatment Plants to be constructed or extended by the Project will use water from Huong River (Quang Te) and its tributaries: Bo River (Tu Ha), Huu Trach River (Binh Thanh) and Khe Tre River (Nam Dong), as well as O Lau River (Hoa Binh Chuong and Phong Tu), Nong river (Loc Bon), Truoi River (Loc An), Khe Su River (Loc Tri) and two unnamed streams in Chan May and A Luoi.

The river flows experience large variations throughout the year due to the contrasted seasons. The water quality parameters of rivers used for the production of drinking water are compliant with the up-dated Vietnamese standards except for phosphate concentration; however, phosphate is not a health concern but may favor growth of algae in water tanks.

Air quality monitoring reveals concentrations markedly exceeding the national standards for dust and slightly exceeding for nitrogen dioxide. Sulfur dioxide and carbon monoxide concentrations are compliant with the standard. Outside of Hue City air quality is supposed to be good given the lack of significant pollution sources. However, noise levels in some places are far above the standards mainly because of the transport sector.

Biological environment

There are three main ecological areas within the Thua Thien Hue Province:

- the mountainous "Green Belt" comprising the Phong Dien Nature Reserve (415 km^2), the Bach Ma National Park (223 km^2) and the woody mountain range which connects these protected areas (in total 1340 km^2). These areas support a number of species found nowhere else in the world such as Saola (Endangered), Edward's Pheasant, Striped Rabbit and the Annam Partridge, as well as the Asian elephant and the tiger (Critically Endangered). Other threatened species are White-cheeked Gibbon, Truong Son Muntjac and Large-antlered (Giant) Muntjac. It is noteworthy that many of these species have been too recently identified for their conservation status to be determined sufficiently.
- the Cau Hai–Tam Giang lagoon complex, which is the larger lagoon of South-East Asia (220 km^2) and one of the richest wetlands of Vietnam (193 species of benthic animals, 230 fish species and 73 bird species)

- the Son Tra–Hai Van coral reef formation, which is the third Vietnamese site in terms of marine biodiversity (70 km^2 and 140 coral species)

Actually, two protected areas are likely to be affected by the project, namely: the existing Bach Ma NP, within which a new water intake station and treatment plant will be set up (Loc Tri subproject), and the proposed Tam Giang-Cau Hai marine protected area, which receives most of the of rivers exploited for raw water abstraction and into which the drinking water treatment sludge is discharged.

Human and socio-economic environment

The population of the TTH Province reached nearly 1.5 million people in 2008, 30% of whom were living in Hue City, which covers only 1.5% of the territory. The remaining population mostly dwells on the coastal and plain area. The mountainous areas only accommodate less than 6% of the population on more than 37% of the territory. The sex ratio is 0.97 and 65% of the population lives in urban areas. In 2007, the measured natural growth rate was 1.26%.

Access to drinking water varies considerably according to the location: tap water is the main source of sanitary water of nearly 95% of households in Hue City but only 5% of households in Phu Loc District who mainly use water from boreholes or wells. For the whole province, piped water is the main source for 52% of households, borehole or well water for 24% of households and other sources (rivers, lakes) for 16% of households. In urban areas, 84% of households use flush toilets equipped with adequate septic tanks and 16% use toilets without impervious septic tank. In rural areas, 57% of households use flush toilets and 42% use "permeable" toilets.

There is a large provincial landfill in Thuy Phuong which has been extended in 2008. Secondary landfills have been recently constructed (A Luoi, Phong Dien) or planned in each district of the THH Province by 2010.

The mountainous A Luoi and Nam Dong districts show the highest incidences of monitored waterborne diseases diarrhea and dysentery. Hue district shows markedly the lowest incidence of dysentery in such a way that it remains the least affected in terms of cases despite that it accounts for 30% of the total province population. Among the other non mountainous districts, the Phu Vang District located in coastal zone and on both sides of the lagoon, shows clearly the most numerous cases of dysentery, which could be explained by the fact that this district shows the lowest rate of households having access to sanitary water. Malaria, not a waterborne but a water-related disease, is only observed in mountainous areas (A Luoi and Nam Dong Districts).Cholera and typhoid cases used to be frequent in the province but these diseases seem to have been eradicated in the last decade.

In 2008, the main employing sectors in the TTH Province were: agriculture and forestry (31.8% of employments), manufacturing (17.6%), trade of goods (12.1%), construction (8.2%), fishing (7.2%), transport (5.5%), hotel and restaurant (5.3%) and education (3.4%). The unemployment rate was 5.5%.

Rice is the main crop cultivated in the TTH Province but ricelands are mainly present in river plains. Fishing and aquaculture sector employs more than 7% of the working population. In 2008, the total fish catch amounted to 26,626 tons among which the sea production was of 19,825 tons.

In 2008, there were 148 hotels and 131 tourist houses in TTH Province, most of them located in Hue City. The Province accommodated 815,786 national visitors and 709,473 foreign visitors during the same year. These figures show an increasing trend.

Outside of Hue city, the average monthly household income was VND3.115.482 (US$173) and the average monthly household expenses VND2.218.599 (US$123).

Hue was the capital city of Vietnam during the Tay Son and Nguyen dynasties. As a result, the cultural heritage in TTH Province is rich and diversified, including both tangible and intangible settings. In recognition of its cultural value the partially-restored citadel in the heart of Hue has been declared a UNESCO World Heritage Site. Other cultural and

historical attractions are the ancient tombs located upriver from Hue on the Huong (Perfume) River which have also been listed by UNESCO as World Cultural Heritage sites.

D. Forecasting Environmental Impacts and Mitigation Measures

Environmental impacts

The main environmental impacts likely to occur during the construction phase are:

- rise of noise and vibration levels and emission of dust and exhaust gases by heavy machinery and vehicles used for earthworks and pipe laying
- loss of natural soil caused by site preparation (scouring), leveling and trench digging
- pollution of soils by oil spillage from engines and lubricant/fuel storage vessels
- pollution of fresh waters by disposal of spoil material
- destruction of terrestrial flora subsequent to the destruction of soil
- damage to private and public goods by the movement of heavy machinery
- disruption to public services (power, water, and telecommunications)
- disruption to road traffic in urban areas
- adverse effects on health and welfare due to noise and polluting emissions
- increased safety risks for nearby populations in residential areas due to excavated areas and circulation of vehicles and heavy machinery

The main environmental impacts which may occur during the operation phase are:

- soil erosion on the scoured strip above pipe routes
- decrease of river flows due to raw water abstraction, which might be harmful to biodiversity or prevent other use of water in downstream stretches
- pollution of fresh water by discharge of treatment sludge containing high amounts of aluminum
- aesthetic damage of pleasant landscapes due to the poor visual impact of new buildings/facilities.

Mitigation measures

Mitigation measure proposed to reduce, avoid or compensate for the impacts are the following;

- environmental requirements for contractors relating to the quality and the maintenance of the equipment used for construction, working hours, liaison with nearby populations, dust prevention by covering trucks and water spreading on dusty roads, reuse and disposal of spoil material, origin of borrowed material, restoration or payment for damage to public/private goods, work sites signalization, speed limits for vehicles, environmental management of fuel, lubricant, liquid and solid waste, protection and re-plantation of adornment trees.
- approval by the management board of Bach Ma National Park of detailed designs of the water intake of the Loc Tri WPT and the raw water pipeline
- tree plantation on 200 ha, performed by local communities through skilled NGOs and under the supervision of Forestry Department

- plantations of autochtonous herbaceous species on the top of the backfilled trenches in natural areas (50 ha in total).
- conducting Environmental Flow Assessments (EFA) for new WTPs using raw water from medium and small size rivers, i.e. Loc Bon (Nong River), Loc An (Truoi River) and Loc Tri (Khe Su River).
- installing drying beds in the WTPs of more than 10,000 m3/d i.e. Phong Tu WTP (210 m2), Tu Ha WTP (120 m2), Loc Bon WTP (300 m2) and Loc An WTP (120 m2).
- landscaping works in Phong Tu WTP, Tu Ha WTP, Loc Bon WTP, Loc Anh WTP and Loc Tri WTP as well as the ten new booster pumping stations.

E. Institutional Requirements and Environmental Monitoring Plan

HUEWACO should recruit for a 5 years period an external Senior Environmental Consultant who will work together with one or two Internal Environmental Officers forming part of HUEWACO technical staff. The main duty of the Senior Environmental Consultant will be to supervise environmental management of works as well as monitoring activities as described below. However, in order to improve environmental management capacity of HUEWACO, he will perform training activities (on-the-job and lectures) mainly focusing on the management of construction works of water utilities. One or both Internal Environmental Officers will replace the Senior Consultant at the end of the five-year contract.

Supervision consultants of the large-scale works should appoint a part time Environmental Supervision Correspondent who will look after environmental management of works and inform the Senior Environmental Consultant as soon as a significant environmental non-compliance is observed and damage or risk of damage due to the contractor. Events impacting the environment will be elaborated in the environmental section of the monthly works progress report.

An Environmental Monitoring Unit (EMU) will be set up, consisting of:

- the Chief of the Project Management Unit (PMU), Chairman
- a representative of the Department of Natural Resource and Environment (DONRE), Vice Chairman
- the Senior Environmental Consultant, Secretary
- the Internal Environmental Officers,
- a representative of the Department of Agriculture and Rural Development (DARD)
- a representative of the Department of Public Health (DOPH)
- for each (major) works contract:
    - the Head of the Construction Supervision team, during the construction stage,
    - the Environmental Supervision Correspondent during the construction stage,
    - representatives of the concerned Commune People's Committees

The main tasks of the EMU will be the following:

- elaborate and validate the environmental requirements and incorporate them into the bidding documents for both Contractors and Supervision consultants.
- ensure, with the help of the Supervision consultants, that the mitigation measures are properly implemented by the contractor during construction.
- review works reports, and notably environmental related sections
- notify HUEWACO of any noticed breach of implementation of mitigation measures (notably environmental practices) by the contractor. In this case, the EMU should propose to HUEWACO adequate remedial measures to be undertaken by the contractor or the institution in charge
- approve the report of environmental acceptance of works
- review and approve monitoring reports (monitoring stage). In case of unexpected impacts, the EMU could suggest remedial measures to the concerned Authorities.

The EMU will be operating starting from the bidding stage and will remain active until three years from the end of the last construction/extension works. The EMU should meet at least every 6 months during the construction stage and every year during the following three-year period of operations. However, on a justified request of any member, extraordinary EMU meetings could also be held.

Environmental monitoring during construction phase will consist of monitoring noise, vibration and dust (total suspended particulate) and checking compliance with the national standards as well as controlling the observance of environmental requirements of contractors using qualitative and quantitative indicators.

During the operation phase, the indicators to be monitored will be pesticides in raw water, metal content of treatment sludge and effluents of Water Treatment Plants, pollutants in river sediment downstream of discharge points and epidemiological data relating to waterborne diseases.

F. Public Consultation and Disclosure

Detailed design of project components will be undertaken later. However initial public consultations have been started and three formal public consultations have been hold at the following places:

- Quang Te (part of Hue City) on the 1rst December 2009
- A Luoi on 15th December 2009, and
- Nam Dong on 17th December 2009

These three locations are priority because they cover either high intensity of works (construction of large WTP at Quang Te) or poorer areas where ethnic minorities reside (A.Luoi and Nam Dong).

During these meetings, the environmental aspects have been exposed together with resettlement issues. First the Project was presented with its strategic framework and specific objectives, its main features in terms of location, technical components and then the layouts of preliminary design in order to clearly show the impacted streets and areas.

Presentation of environmental aspects was comprised of:

- the main biophysical impacts and human impacts likely to arise during the project implementation, especially in construction stage
- the measures anticipated with a view of mitigating these impacts
- the indicators that will be monitored during both construction and operation phases.

No major concerns were expressed in the comments of the affected people present at the meetings. Generally speaking, people consider that improvement of water supply is so critical that they can accept shortcomings associated with construction phase, especially since the main expected impacts will be properly mitigated.

G. Findings, recommendations and conclusions

The implementation of the Thua Thien Hue Province Water Supply Project will be critical for the improvement of water supply throughout the whole TTH province and subsequently for health conditions among the resident population including the most vulnerable.

The Project consists of works in eleven water supply areas with subprojects including at least one of the three following components:

(a) construction/extension of a drinking water treatment plant and its ancillary equipment (water intake),
(b) construction of booster pumping station and
(c) laying of water distribution pipe network.

These subprojects are spread out over the whole of the TTH province and will use water from ten rivers, of which four belong to the same catchment basin (Huong, Bo, Huu Trach. and Khe Tre rivers).

Public consultation process has been initiated for three sub-projects but needs to be completed throughout the province.

One of the subprojects (Loc An) is located in the buffer zone of a protected area (Bach Ma National Park) and another one (Loc Tri) is partly located within the core territory of the same park (water intake and raw water supply pipeline), however, no major impacts or impacts which cannot be mitigated are expected from the implementation of both subprojects.

The main impacts likely to be caused by the Project are:

- *damage to soil and vegetation and nuisance to nearby population in the construction phase, especially when laying the water pipe networks. This will be mitigated through environmental requirements for contractors.*
- *the risk of important depletion of the water flows subsequent to the water abstraction for drinking water production. This will be mitigated by the performance of environmental flow assessment.*
- *the discharge of treatment sludge (aluminum) into the watercourses. This will be mitigated through sludge treatment prior to discharge.*

To ensure that the environmental impacts will be adequately managed it is proposed to recruit a Senior Environment Consultant for 5 years. A usual approach is to totally rely on the supervision team to deal with environmental supervision of the works but in this case, as many subprojects or part of subprojects are likely to be attributed to different contractors of diverse size, it would be difficult for each of them to mobilize skilled environmental supervisors. Accordingly a "central" multi-site supervision has been preferred for this project. The Senior Environment Consultant will also be in charge of training HUEWACO junior engineers on-the-job and all relevant management staff by lectures.

It is important to remember that this IEE has considered that the recommendations issued by the water resources specialist (Water Conservation Issues in Thua Thien Hue Province: Threats and Possible Responses, August 2009) will be observed by HUEWACO in the short and medium terms and that a programme for ISO certification will be implemented.

Eventually, the positive effects of the Project will be dramatically enhanced if an adequate program is implemented for improving access to drinking water to the population dwelling far away from water supply networks (particularly in the mountainous areas) and to the boat people. Both aspects have been addressed by ADB consultants in the framework of this Project.

1. INTRODUCTION

1.1. PROJECT BACKGROUND

The Project subject to this Initial Environmental Examination (IEE) consists in improving water supply to seven districts and one city (Hue City) of the Thua Thien Hue Province (TTH Province). The Project is comprised of a set of sub-projects which include:

- construction and/or extension of drinking Water Treatment Plants (WTPs) with or without new water intake stations
- construction of new booster stations
- construction/extension of water pipe network, size from 100 to 1200mm diameter

Project implementation will extend over 10 years in two phases 2010 – 2015 and 2016 – 2020.

At the request of the Vietnamese Government, the Asian Development Bank (ADB) has agreed to provide Technical Assistance (TA) to prepare the Thua Thien Hue Water Supply Project. The Executing Agency is the Thua Thien Hue People's Committee who has delegated responsibility primarily to the Thua Thien Hue Water Supply Company (HUEWACO).

Improved access to water supply and sanitation is amongst the most pressing needs of the residents of the Thua Thien Hue Province, particularly the poor people living in the remote, rural areas which are often prone to waterborne diseases. Domestic water supplies and environmental sanitation contribute to livelihoods in a wide range of ways. They are crucial to health and well-being, and can make an important contribution to food production and income generating activities. However, as demand for water rises due to increasing populations and industrial development, many parts of the province will face increasing water scarcity and pollution risks.

The Steering Committee for the Project was established by Decision Ref. No. 1162/QD-UBND signed by the Chairman of the People's Committee of Thua Thien Hue Province on 8 July 2009.

1.2. PURPOSE OF THE REPORT

The overall objective of this PPTA (7089-VIE) is to prepare for ADB financing of the proposed Thua Thien Hue Water Supply Project. The Project was screened and classified as an Environmental Category B project which requires an Initial Environmental Evaluation (IEE).

The objectives of the IEE are, according to the ADB's Safeguard Policy Statement (2009):

- to identify potential direct, indirect, cumulative and induced environmental impacts on and risks to physical, biological, socioeconomic, and physical cultural resources and determine their significance and scope,
- to examine alternatives to the project's location, design, technology, and components that would avoid, and, if avoidance is not possible, minimize adverse environmental impacts and risks
- to prepare an environmental management plan (EMP) that addresses the potential impacts and risks identified by the environmental assessment. The EMP will include the proposed mitigation measures, environmental monitoring and reporting requirements, emergency response procedures, related institutional or organizational

arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators.

In accordance to these requirements, this report will be a management tool aiming at a better integration of the project to its biophysical and human environment.

1.3. EXTENT OF THE IEE STUDY

As mentioned above, the Thua Thien Hue Water Supply Project consists in many subprojects to be implemented in many places spread out in the all territory of the TTH Province, from the inland mountains down to the coastal plains and seashore. Moreover, detailed design study, even the location of certain WTP, was not finalized by the end of the Consultant's on-site mission.

For these reasons, and also because some data are not available at smaller scale, the description of the existing environment basically presents all the environmental features likely to be encountered over the all TTH Province. It is however obvious that whenever the need arose, the consultant did study in greater detail the topics of critical importance for the project impact assessment, such as river flow and water quality, areas of ecological interest affected by the project or burden of waterborne diseases. As much as possible, specific environmental settings of the project sites will be described at an adequate scale.

Another crucial point is that no mitigation measure has been proposed without carefully examining its adequacy and relevance to the specific environmental setting of the subprojects. As a result, some measures apply to several subprojects while some others only apply to one or a few subprojects.

2. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1. POLICY AND LEGAL ENVIRONMENTAL FRAMEWORK

The environmental policies for sustainable development of Vietnam were first systematically presented in the "National Plan on Environment and Sustainable Development, 1991-2000". Since then, the Government has promulgated a series of policies for environmental protection and sustainable development in different sectors such as forest, clean technologies, biodiversity, potable water and sanitation.

The new Vietnam Law on Environmental Protection dated 19 November 2005 (LEP 2005) provides an umbrella framework for environmental management and protection in Vietnam, and the prime authority is the Ministry of National Resources and Environment (MONRE). The LEP provides for the protection of the environment with a view to protecting the health of the people, serving the cause of sustainable development of the country and contributing to the protection of the regional and global environment.

Decree 80/2006/ND-CP in conjunction with Decree 21/2008/ND-CP distinguishes two categories of projects: (i) projects requiring an Environmental Impact Assessment (EIA) and (ii) projects requiring a simpler Environmental Protection Commitment (EPC). The difference between the two processes reflects the level of assessment, and review and appraisal required. Circular 05/TT-BTNMT supports the aforementioned Decrees with technical guidance for preparing and reporting both levels of assessments.

In 2003 the MONRE have formulated the "National Strategy for Environmental Protection to 2010 and Orientation to 2020". The provinces and cities are also formulating their local environment protection strategies to 2010.

The Law on Water Resources (No.8/1998/QHIO) was promulgated in May 1998 and came into effect in January 1999. The objective of this Law is to enhance the national management efficiency and responsibility of various bodies; to protect, exploit, utilize water resource as well as to give prevention and mitigation measures for only adverse impact by water. The Ministry of Agriculture and Rural Development is bound within implementation of this Law.

More than 10 regulation standards have been issued since 15 years with respect to the quality of raw, drinking and wastewater, the more relevant to the project being the following (see details in Annex):

- TCVN 5945:2005: Industrial waste discharge standards
- QCVN 08:2008/BTMNT: Surface water quality standards
- QCVN 09:2008/BTMNT: Groundwater quality standards
- QCVN 10:2008/BTMNT: Coastal water quality standards

With respect to the other environmental components which are likely to be impacted by the project, standards have also been issued, in particular:

- TCVN 5949:1998 - Noise in public and residential areas: maximum permitted noise levels
- TCVN 6962:2001: Vibration emitted by construction works: maximum permitted levels in the environment of public and residential areas

Vietnamese water regulation and standards seem to have been renewed at a quite furious pace since few years ago, new standards replacing the former ones, causing sometimes a possible confusion among actual requirements in terms of water quality.

Viet Nam has ratified the main international conventions relating to biodiversity, including the Convention on Biological Diversity, the RAMSAR Convention on Wetland of International Importance, the Convention on the Protection of the World Cultural and Natural Heritage and the Convention on the International Trade of Endangered Species of Wild Fauna and Floras (CITES).

2.2. ENVIRONMENTAL INSTITUTIONS

The Ministry of Natural Resource and Environment (MONRE) is from 2002 responsible for the management of the environment at the national level. Within the MONRE, there are three main operational services:

- the Department of Environment (DOE) which assist the Minister in policy-making and development of related legislations, strategies, planning and plans.
- the Department of Appraisal and EIA (DAEIA) which is responsible for the implementation of impacts assessment and appraisal procedures, and
- the Vietnam Environmental Protection Agency (VEPA) which is responsible for applying the policies and regulation in terms of environmental inspectorate and supervision, pollution prevention, environmental quality improvement, natural conservation, environmental technology promotion and public awareness enhancement.

At present Environmental Protection Agencies are operating at the Province level (Department of National Resources and Environment or DONRE).

DONRE of TTH Province has several technical divisions, including Land Management Division, Mineral Resources Division, Division of Natural Waters and Hydrometeorology, Environmental Management Division, Division of Sea, Office of Cartographic Survey, Division of Land Use Registration and Environmental Inspectorate. The DONRE has competence in controlling, monitoring the implementation of the mitigation and Environmental Management Plans (EMP) during construction and operation phases. It can conduct monitoring activities related to, e.g. water, air quality, erosion, and pollution.

Generally speaking, water supply projects involve several ministries including: Ministry of Construction, Ministry of Planning and Investment, Ministry of Agricultural and Rural Development (responsible for water resources), Ministry of Natural Resources and Environment (impact assessment), Ministry of Health (quality control of raw water).

Management and development of potable water supply in TTH Province is the responsibility of the Hue Water Corporation (HUEWACO), which is subsequently responsible for the environmental assessment and management of their water supply development projects.

According to the LEP (2005) and related Decrees (see the above paragraph), HUEWACO shall prepare an environmental impact assessment (EIA) of the Water Supply Project in compliance with the requirements of the African Development Bank (ADB). The Environmental Management Plan (EMP) elaborated in the framework of the EIA shall be implemented under HUEWACO direction and responsibility.

2.3. ADB ENVIRONMENTAL POLICIES AND PROCEDURES

ADB affirms that environmental and social sustainability is a cornerstone of economic growth and poverty reduction and is committed to ensuring the social and environmental sustainability of the projects it supports. With this aim ADB set out Safeguard Policies the objectives of which is notably to avoid adverse impacts of projects on the environment and affected people, where possible or minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible. The Safeguard Policies of ADB include (i) Environmental Safeguards, (ii)

Involuntary Resettlement Safeguards and (iii) Indigene People Safeguards. Revised safeguard requirements have been recently (2009) issued by ADB. All projects funded by ADB must undergo environmental impact assessment which begins by a screening phase which result in the classification of the project into 3 main categories: (i) Category A for projects likely to cause significant adverse environmental impacts that are irreversible, diverse, or unprecedented, (ii) Category B for projects causing impacts less adverse than de category A project, in particular impacts which can be easily mitigated and Category C for project likely to have minimal or no adverse impacts.

Depending on the significance of project impacts and risks, the assessment may comprise a full-scale Environmental Impact Assessment (EIA) for Category A projects, an Initial Environmental Examination (IEE) or equivalent process for Category B projects, or a desk review of potential impact for Category C projects. It is remembered that the present project falls into Category B and thus should undergo an IEE.

The environmental screening is carried out by ADB but the borrower/client is responsible for assessing projects and their environmental and social impacts, preparing safeguard plans, and engaging with affected communities through information disclosure, consultation, and informed participation following all policy principles and safeguard requirements. The borrower/client will submit all required information, including assessment reports, safeguard plans/frameworks, and monitoring reports, to ADB for review.

To ensure that contractors appropriately implement the agreed measures, the borrower/client will include the safeguard requirements in bidding documents and civil works contracts. Where national safeguard policies and regulations differ from ADB's safeguard policy statement including Safeguard Requirements 1–4, ADB and the borrower/client will formulate and agree on specific measures to ensure that ADB's safeguard policy principles and requirements are fully complied with.

3. DESCRIPTION OF THE PROJECT

3.1. LOCATION OF THE PROJECT

The present Project extents to the entire Thua Thien Hue (TTH) Province, which is located in Central Vietnam and stretches from latitude 16.00° to 16.80° east and 107.80° to 108.20° north. The Province territory covers an area of 5,051 km^2, delimited to the North by the Quang Tri Province, to the South by the Da Nang City, to the East by the Pacific Ocean and to the West by the Cambodian border (see Fig. 1).

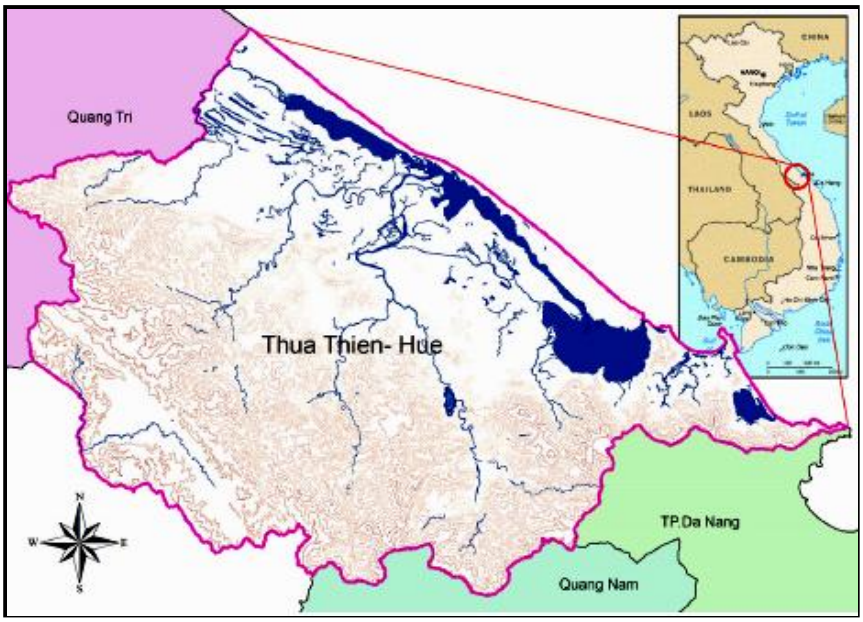


Figure 1: The Tua Thien Hue Province

3.2. MAIN COMPONENTS OF THE PROJECT

The Project is still in feasibility stage and the technical design is not yet fully completed. Even the precise location of some facilities is still under discussion. However, the outline indicated hereinabove reflects the most recent state of design and only details may change by the end of the design stage.

With regard to water supply, eleven demand zones have been defined within the TTH Province which are supposed to be supplied by autonomous systems mainly comprising one or several water treatment plants (WTP), booster pumping stations with their water tank as well as water main and distribution network, which will serve most of the water consumers located in the zone (households, public and private facilities and industries).

The present Project will hence serve the high water demand zones and provide the investments needed to meet water requirements estimated from both forecasted population and economical growths by 2015 and 2020. The anticipated investment and relating infrastructures are summarized in Table 3.1 and set out in Figure 2.

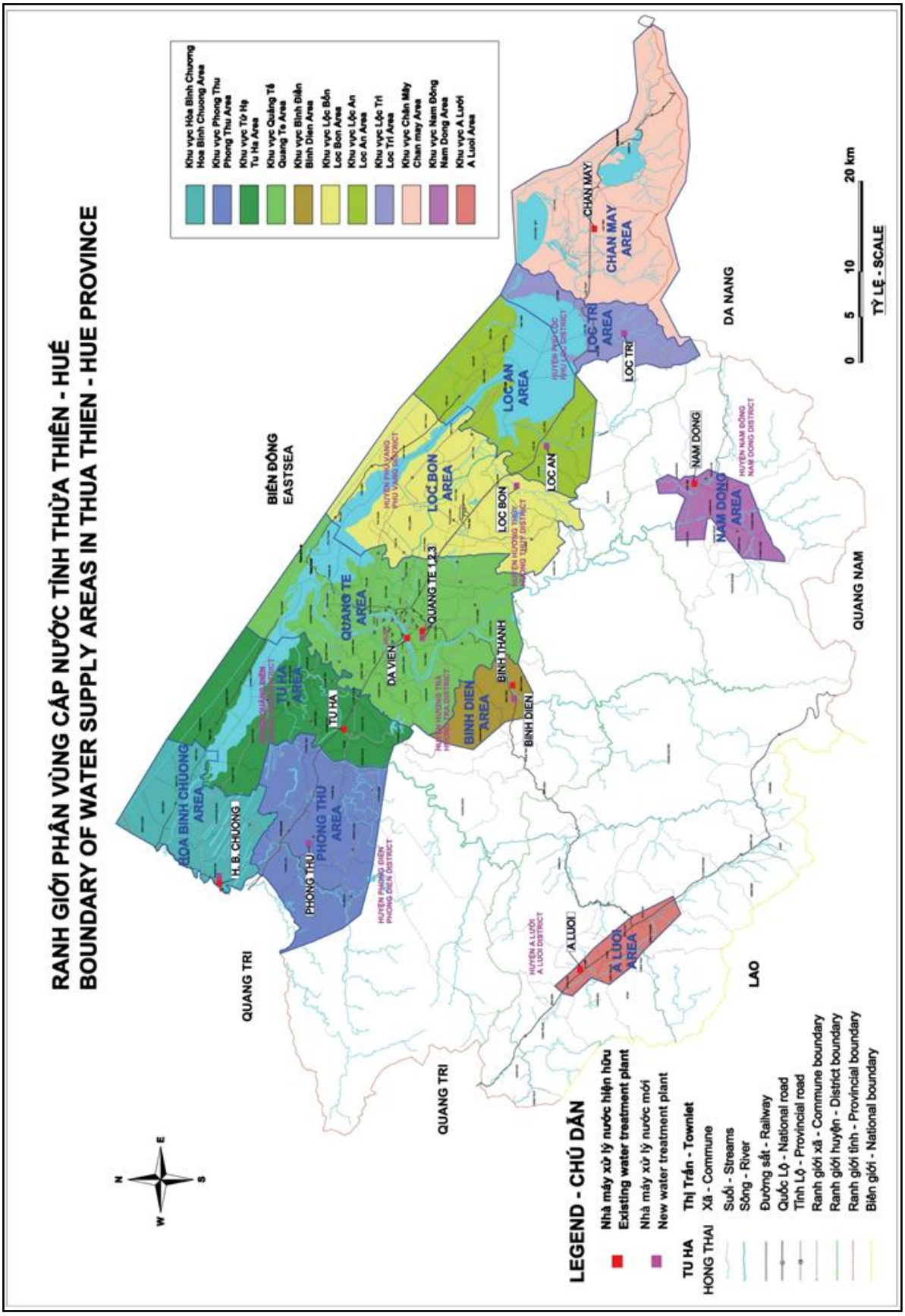
Table 3.1: Outline of the proposed Water Supply Project for the TTH Province

Sub-project	Water Treatment Plants					Booster Pumping Stations (new construction)	Main pipelines (new installation)
	Name/Location	Source	Existing Capacity	2015 Capacity and Surface Area	2020 Total Capacity	2015	2015
1 Hoa Binh Chuong	Hoa Binh Chuong	O Lau River	2,000 m^3/day	2,000 m^3/day	2,000 m^3/day		75 km D50 - D250
	Dien Mon	O Lau River	0 (not yet built)	**3,000 m^3/d Land use: WTP and PS: 10,000 m^2**	3,000 m^3/day		
2 Phong Thu	Phong Dien	O Lau river	0 (not yet built)	**8,000 m^3/day Land use: WTP and PS: 15,000 m^2**	21,000 m^3/day	Dong Lam 1,000 m^3/day (3,000 m^3/day up to 2020)	120km D50 – 400
3 Quang Te (Hue and suburbs)	Van Nien RWPS	Huong river	120,000 m^3/day	240,000 m^3/day	320,000 m^3/day	Thuan An 2,000 m^3/day (4,000 m^3/day up to 2020) Huong Vinh 1,500 m^3/day (1,500 m^3/day up to 2020)	185 km D50 – D1200
	Quang Te 1	Huong river	40,000 m^3/day	Closed	Closed		
	Quang Te 2	Huong river	82,500 m^3/day	82,500 m^3/day	82,500 m^3/day		
	Quang Te 3	Huong river	0 (not yet built)	**90,000 m^3/day Land use: WTP: 58,000 m^2**	180,000 m^3/day		
	Da Vien	Huong river	12,000 m^3/day	0 (closed)	0 (closed)		
4 Tu Ha	Tu Ha	Bo river	12,000 m^3/day	32,000 m^3/day	32,000 m^3/day	Sia 1,500 m^3/day (1,500m3/d up to 2020)	135 km D50 – D300
5 Binh Dien	Binh Thanh	Huu Trach river	250 m^3/day	250 m^3/day	250 m^3/day		30 km D50 – D200
	Binh Dien	Thuong Ngan waterfall	500 m^3/day	1,000 m^3/day (New WTP and decommissioning old one)	2,000 m^3/day		

6 Loc Bon	Phu Bai	Groundwater	1,800 m^3/day	1,800 m^3/day	1,800 m^3/day	Thanh Ha 250 m^3/day (250m3/d up to 2020)	125 km D50 – D500
	Loc Bon	Nong river	0 (not yet built)	**20,000 m^3/day Land use: WTP and PS: 11,000 m^2**	30,000 m^3/day		
7 Loc An	Loc An	Truoi river	0 (not yet built)	**8,000 m^3/day Land use: WTP and PS: 15,000 m^2**	12,000 m^3/day		110 km D50 – D500
	Vinh Hien	Groundwater	100 m^3 /day	0 (closed)	0 (closed)		
8 Loc Tri	Loc Tri	Su stream	0 (not yet built)	**2,000 m^3/day Land use: WTP 10,000 m^2**	4,000 m^3/day		35 km D50 – D250
	Loc Binh	Lang stream	0 (not yet built)	**2,000 m^3/day Land use: WTP 10,000 m^2**	2,000 m^3/day		
9 Chan May	Chan May	Bo Ghe stream	6,000 m^3 /day	8,000 m^3/day	8,000 m^3/day		80 km D50 – D350
	Thuy Cam	Thuy Cam lake	0 (not yet built)	0 (not yet built)	**8,000 m^3/day Land use: WTP: 15,000 m^2**		
10 Nam Dong	Nam Dong	Ta Trach river	2,000 m^3/day	2,000 m^3/day	2,000 m^3/day		85 km D50 – D200
	Thuong Long	Thuong Nhat river	0 (not yet built)	**2,000 m^3/day Land use: WTP and PS: 10,000 m^2**	2,000 m^3/day		
11 A Luoi	A Luoi	Ta Re stream	2,000 m^3/day	4,000 m^3/day	4,000 m^3/day		95 km D50 – D200

Acronym/legend: **WTP**: water treatment plant **PS**: pumping station (for water off-take) **New construction** Upgrading with surface extension Upgrading without surface extension

Figure 2: Boundaries of water supply areas in Thua Thien Hue Province



Summarily, the proposed Project provides, from 2011 to 2016, for:

- Construction of eight new water treatment plants (WTP) and five new off-take pumping stations. These include :

  Water treatment plants: Phong Dien, Dien Mon, Quang Te 3, Loc Bon, Loc An, Loc Tri, Loc Binh, Thuong Long

  Off-take pumping stations: Phong Dien, Loc An, , Loc Bon, Thuong Long, Dien Mon

- Closure of three existing WTPs. These include : Quang Te 1, Da Vien, Vinh Hien

- Capacity upgrade of four existing WTP, of which three with surface extension. These include : Tu Ha (surface extension and capacity upgrade from 12,000 m3/day to 32,000 m3/day), Binh Dien (surface extension and capacity upgrade from 500 m3/day to 1,000 m3/day), Chan May (capacity upgrade from 6,000 m3/day to 8,000 m3/day), A Lưới (surface extension and capacity upgrade from 2,000 m3/day to 4,000 m3/day)

- Capacity upgrade and surface extension of Van Nien raw water pumping station, the construction of water museum at Van Nien

- Construction of five new booster pumping stations

- Laying nearly 1,075 km of pipes for transmission and distribution network (diameter from 50 to 1200 mm).

More details, especially those regarding the description of treatment vessels, size and location of the distribution network on the project components are given in the feasibility report.

With respect to environmental assessment, the project can be divided into a total of eleven “impacting” subprojects as follows:

- Hoa Binh Chuong subproject
- Phong Tu subproject
- Quang Te subproject
- Tu Ha subproject
- Bin Thanh subproject
- Loc Bon subproject
- Loc An subproject
- Loc Tri subproject
- Chan May subproject
- Nam Dong subproject
- A Luoi subproject

The different works anticipated in each subproject are described Table 3.2.

Table 3.2: Works anticipated for the water supply subprojects

Subproject	District	WTP	WTP	Booster station	Pipe network
		Construction	Extension	Construction	Construction
Hoa Binh Chuong	Phong Dien	-	1	2	21.5 km
Phong Tu	Phong Dien	1	1	1	29.3 km
Quang Te	Hue City	1	1	2	62.7 km
Tu Ha	Huong Tra	-	-	3	44.1 km
Bin Thanh	Huong Tra	-	1	-	15.3 km
Loc Bon	Huong Thuy	1	1	2	60.5 km
Loc An	Phu Loc	1	1	-	55.6 km
Loc Tri	Phu Loc	1	1	-	11.4 km
Chan May	Phu Loc	-	1	-	29.9 km
Nam Dong	Nam dong	-	-	-	34.1 km
A Luoi	A Luoi	-	1	-	34.4 km

For the subprojects, the present Initial Environmental Examination (IEE) will consider the three following project stages:

- preconstruction stage (detail design)
- construction stage (building facilities and laying the pipes), and
- operational phase (water abstraction, treatment, transport and distribution as well as disposal of by-product such as treatment sludge)

3.3. CATEGORY OF PROJECT (ENVIRONMENTAL SCREENING)

The Thua Thien Hue Province Water Supply Project (ADB TA 7089-VIE) was initially screened and classified as an Environmental Category B project which requires an Initial Environmental Evaluation (IEE). Water supply projects, the beneficial outcome of which are obvious, are frequently of Environmental Category B because the affect usually limited land surfaces and do not cause major or immitigable nuisance to the natural and human environment during both construction and operation phases.

4. DESCRIPTION OF THE ENVIRONMENT

4.1. PHYSICAL RESOURCES

4.1.1. GEOLOGY/SEISMOLOGY

Two main categories of geological substrate can be found on the territory of TTH Province (see Fig. 3):

- mountainous and hilly areas are underlain by Paleozoic and Mesozoic rocks, which are either magmatic, acidic such as granite, grano-diorite, diorite and gabbro, either metamorphic such as shale and sandstone, or volcanic such as andesite (in the highest places)
- coastal plains are mostly underlain by Cainozoic sedimentary rocks such as sand, clays, silt, pebble and grave

Old sedimentary rocks such as Devon limestone (fractured) are also found in the southern part of the Province. These rocks often form aquifer of greater interest for the groundwater abstraction.

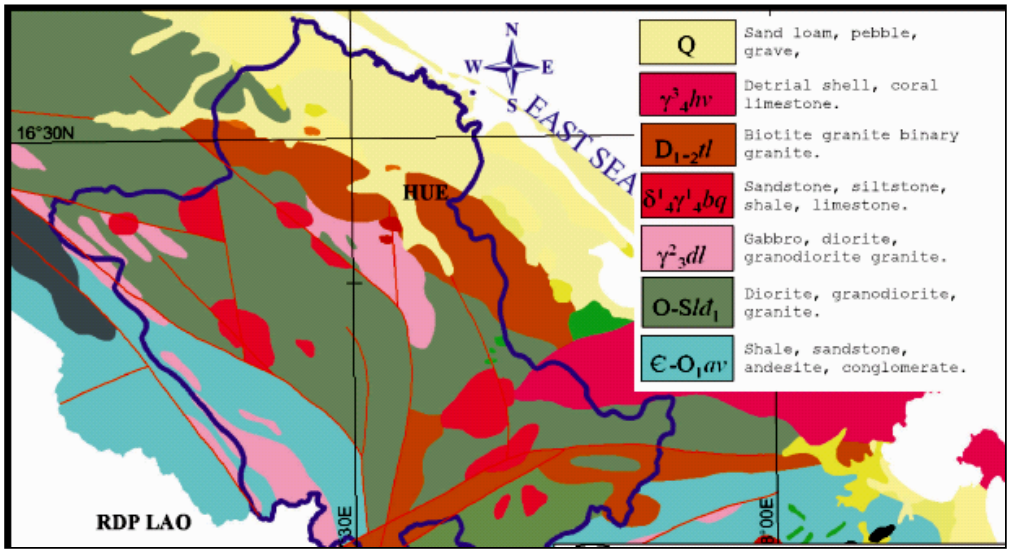


Figure 3: Lithology of the TTH Province (blue line: limit of the Huong River basin)

4.1.2. CLIMATE

4.1.2.1. General Features

Thua Thien Hue Province has a monsoon tropical climate showing two marked seasons: the dry season from January to October and the rainy season from September to December. Actually, in coastal plain the rainy season starts from September and ends in December, lasting 4 months and dry season from January to August, lasting 8 months whereas in mountainous area, the rainy season starts from May or June, and ends in December, lasting 7–8 months, dry season from January to April or May, lasting 4–5 months. Most often, October and November together account for more than 50% of the total annual rainfall (see Fig 4).

The average annual rainfall in Hue has been around 3400 mm over the five last years (2004-2008). However, due to the mountainous morphology, the direction of prevailing

winds, and the general circulation of wet air masses, the western and southern parts of the Province experience an even rainier climate: 4450 mm/year in Nam Dong and 4050 mm/year in A Luoi (for the same period). It is worth noting that the rainfall recorded over the last five or ten years seems significantly higher than that calculated over a longer period and usually cited in many documents (2800 mm/year in Hue). Whatever the measurement period, a small rainy season always occurs in April and May, especially in the highlands. This rise of rainfall is however consistent with that observed recently in many tropical countries.

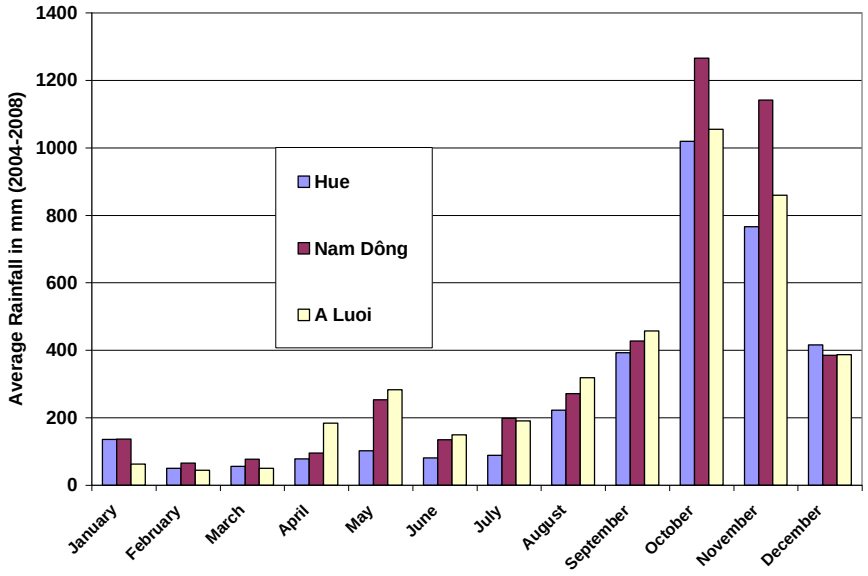


Figure 4: Average monthly rainfall in Hue, Nam Dong and A Luoi for the 2004-2008 period

Daily rainfall may be very abundant: for example, during the first week of November 1999, the city of Hue experienced the highest value recorded in Vietnam for the 24h rainfall, which was 1,384mm.

In general, the distribution of rainy days is suitable for rainfall distribution. On average every year there are about 200–220 rainy days in mountainous area, 150-170 rainy days in the plain. In rainy season months, each month has 16–24 rainy days, in dry season, each month has 8–16 rainy days.

Relative humidity varies from 80% in July and 95% in January. The average monthly sunshine is nearly 150 hours in Hue and 130 hours in A Luoi. The sunnier months are May, June and July (over 200 hours/month in Hue) and the less sunny are December and January (below 80 hours/month in Hue).

Over the five last years, the average temperature has been 24.7 °C in Hue, 24.5 °C in Nam Dong and 21,7 °C in A Luoi. In Hue, the average temperature is around 29 °C in May, June and July and around 20 °C in December - January. The temperatures are logically cooler in the mountainous areas: respectively around 25°C and 17°C in A Luoi for the same months.

The average yearly evaporation over the three past decades is 933 mm in Hue, 919 mm in A Luoi and 858 mm in Nam Dong. These are far lower than the annual rainfall, but on soil with low water retention capacity, some plants may suffer from water shortage in the February-June period.

In Hue, the prevailing winds are North-West from October to April, South and South-West from May to August and North-West. In September, the wind rose is rather balanced, but the East Wind s very rare. In mountainous areas, the winds is influenced by

the relief, so in Nam Dong, the prevailing winds are either South-East or North-West and in A Luoi, the prevailing winds are North-East from September to April and North-West and West the rest of the year. The frequency of calm winds is rather high: 38% in Hue, 26% in Nam Dong and 40% in A Luoi. In Hue and Nam Dong, most of the winds are below 3m/s but in A Luoi, winds over 3m/s are the most frequent from May to August.

4.1.2.2. Cyclones and floods

Due to its geographical location, the TTH Province is often hit by tropical storms and cyclones. These events may generate heavy rains, especially when cyclones coincide with cold air masses coming from the north at the end of autumn – early winter. In this case the runoff waters falling on the mountain slopes very quickly flow down to the lowland and dramatically raise the level of Huong River and Bo River. Since cyclones frequently cause storm surges raising the sea level, the water cannot drain and generates flooding on the lowland, particularly in the vicinity of the main river beds.

The most recent serious event was by the tropical cyclone Eve in November 1999, which was in fact a rather moderate storm by its wind strength but induced weeks of heavy rainfall, amounting to 2288 mm in Hue, that caused the worst flooding in the TTH Province ever in 50 years. In the first days of November 1999 most of the rivers in the central coast were above their highest alarm levels. The water level of the Huong River measured on November 1rst in Hue was 5.6 m above the mean sea level. Because of high inundation level, the lagoon barrier was broken at six different sections. Among those the breach at Hoa Duan commune was the largest with the final width of about 700 m and depth of 5-9 m. In this serious flooding event, 352 people were drowned and 25,056 houses were washed away. Several serious incident have occurred before 1999 (7 people killed in October 1992, 193 people killed in October 1989 (two events), 604 people killed in October 1985, 252 people killed in October 1983, 173 people killed in September 1980) and some other, fortunately less disastrous occurred more recently (2003 and 2009).

4.1.3. MORPHOLOGY AND TOPOGRAPHY

Although the territory of the TTH Province is rather narrow (80 km perpendicular to the coast), its morphology is very diverse, with an overall slope from the mountainous western zones to the flat coastal eastern lowlands and sea shore. About two quarters of the total land (5,054km^2) is occupied by mountains and hills. The main morphologic features of each water supply subproject are described Table 4.1.

Four main morphological situations can be observed in the TTH Province:

- mountainous and hilly uplands, which are found to the west, along the Laotian border and to the south along the limit of Da Nang Province. The western mountainous area is a part of the Truong Son Mountain Range with many high peaks such as Dong Ngai peak at 1,774m and Dong Pho peak at 1,346m. The southern mountainous and hilly area is Bach Ma Range starting from the Truong Son Mountains protruding to the sea with peaks higher than 1000m. The distance from the high mountainous area down to the coastal plain is mot more than 50km which results in steep slopes for the river catchment basins, fostering soil erosion and sediment transport by the runoff.

Table 4.1: Prevailing topography of the water supply subprojects

Subproject	Topography	Altitudes
Hoa Binh Chuong	Coastal low land	<10 m
Phong Tu	Low river plain	<50 m
Quang Te	Low river plain	<50 m
Tu Ha	Low river plain	<50 m
Bin Thanh	Plain	50-200 m
Loc Bon	Low river plain	<50 m
Loc An	Low river plain	<50 m
Loc Tri	Hilly land	100-500 m
Chan May	Coastal low land	<10 m
Nam Dong	Hilly land	100-500 m
A Luoi	Mountainous uplands	500-1000 m

- river plains, dominated by the 500km^2-wide plain of Huong River. This plain shows very gentle slopes. The elevations are comprised between 10 and (-) 1.5 m. Most of the plain is made of hollow areas occupied by rice fields.
- coastal lowlands. These lands are mainly occupied by a very large lagoon complex stretching over 68 km, i.e. almost all length of the coast of TTH Province, parallel with the seashore and called "Tam Giang-Cau Hai Lagoon" (see detailed description § 4.1.7.1). All big rivers in the area such as O Lau, Huong, Nong and Truoi Rivers pour into Tam Giang- Cau Hai Lagoon, which opens to the East Sea (Gulf of Tonkin) mainly by Thuan An Channel (Huong River's estuary in the middle of the Lagoon), and Tu Hien Channel at the south-eastern end of the Lagoon). To the south-eastern end of the Province, there is a moderate size lagoon (5km x 4 km)called An Cu Swamp, which seems not having been subject to thorough study,
- seashore, which is mostly sandy and strait, apart from rocky outcrops of Bach Ma Range in the south-eastern end of the Province coast. The first outcrop forms a small bay (Chan May Bay) and the second forms a small island (Son Tra Island). The coastal sand area is mainly a series of sand dunes which is 71km long and about 2.5km wide.

4.1.4. SOILS

Soil typology of TTH Province is not only contributed by bedrock and climate, but also by topography and hydromorphy (shallowness of the water table).

The mountainous and hilly uplands are covered with Ferric Acrisols (332,000 ha, i.e. 70% of the Province's total land surface) the property of which depends on the bedrocks:

- Ferric Acrisols developed on sandstone and granitic (159,000 ha) are rather deep (1.5 m), have a heavy texture (high proportion of clay), are rich in organic matter and phosphorus, average in nitrogen but poor in potassium and others bases. They are very frequent in A Luoi and Phong Dien Districts). These good quality soils are used for mountainous agriculture and forestry.
- Ferric Acrisols developed on magmatic rocks (135,500 ha) are quite shallow with a light texture (sandy soils). They are acid, poor in organic matter, nitrogen and phosphorus, but rather rich in potassium. These soils are suitable for agriculture but

need fertilizers. They are well distributed over the Nam Dong, A Luoi, Huong Thui and Huong Tra Districts.

- Ferric Acrisols developed on sand material (37,500 ha) are very light (sandy soils) and shallow (less than 60 cm). They are poor inorganic matters and nutrients. Their water retention capacity is also low. On the gentle slopes, these oils can be planted with not demanding crops (legumes), but on the steeper slope, forestry and tree crops are recommended to control erosion. These soils are mostly found in Phong Dien District.

Humic Acrisols (16,000 ha, i.e. 5% of the Province's total land surface) can also be found in the mountainous regions, at high altitudes (above 900m). These soils are rather thick, rich in organic matter and nutriments (expect potassium) and have a light texture. They are occupied by forest in the top of mountains but can be cultivated in the lower altitude. These soils are mostly found in A Luoi and Nam Dong Districts.

Xanthic Ferralsols (4900 ha) are developed on gabbros and diorites in mountainous zones, mainly in Nam Dong District. They are thick (2-3 m), fairly acid, with a heavy texture and a high level of organic matters, nitrogen and phosphorus, but a deficiency in potassium. These soils are the richest that can be found in highlands and are particularly used to cultivate valuable crops such as coffee trees, tea plants and heveas.

In intermediate zones one can find Dystric Plinthosols (4800 ha) which alternate dry and flooding period resulting in iron segregation and hard concretions (the "plinthic" horizon). These soils are mainly used for rice cultivation. They are distributed around Hue City and over the entire Province except A Luoi and Nam Dong Districts.

In some sloppy places, erosion has removed the organic top layer and consequently formed Leptosols (5200 ha), which show a very nutrient content. These eroded soils need to be restored by protection against runoff and tree plantations. They are mainly found in Phu Loc and Phong Dien Districts.

The river flood plains are mainly occupied by recent Fluvisols (46,400 ha, i.e. 10 % of the Province's total land surface) developed on rivers deposits. These show a wide range of textures and are also discriminated by their level of hydromorphy (permanent/intermittent presence of free water the soil profile):

- Molli-salic Fluvisols (6,100 ha) show neutral reaction, medium level in organic matters, nitrogen and potassium, but a low phosphorus content. These soils are suitable for rice cultivation and can be found in the vicinity of river courses in Phu Vang, Hu Loc, Huong Tra and Quang Dien Districts.

- Hyperthionic Fluvisols (6,900 ha) are very sour and show high nutrient level, but they also contents sulphide which is toxic to many plants. They are generally not cultivated but occupied by hydrophilic grasses such as Cyperaceae (*Eleocharis dulcis*, *Cyperus malaccensis*) or shrubs such as cajuput (*Melaleuca leucadendra*). These soils can be found in all Districts except in A Luoi and Nam Dong.

- Dystric Fluvisols (27,400 ha) are the most frequent of the hydromorphic soils. These soils are very diverse in terms of texture, but featured by a fairly acid reaction, a low level in organic matter, nitrogen and phosphorus, but medium level in potassium and other bases. Subcategories of Dystric Fluvisoil can be identified according the flooding period and the mechanical composition. If the soils are not flooded, or only during a short period, they can be cultivated with classical rainfed crops (crop rotation system), at the places where the flooding period is quite long, the soils are mainly used as riceland. These soils are distributed all over the Province, including Hue City and even in the vicinity of coastal sand dune, except in A Luoi and Nam Dong Districts

- Gleyic Fluvisols (6000 ha) are featured by heavy texture (high clay content), which favours during flooding the reduction of some elements such as iron (ferrous ion). These soils are mostly suitable for rice crop. They can be found in Phu Loc, Phu Vang, Huong Tra and Quang Dien Districts.

On coastal sand deposit have developed Arenosols (44,000 ha, i.e. 9% of the Province's total land surface). These soils are featured with a very light texture (high sand content) and a low nutrient level. According to the location and the presence of an organic top layer, two subcategories can be distinguished:

- Luvic Arenosols (24,400 ha) have developed on the sand dunes bordering the seashore. These soils are very poor in nutriments and not cultivated. However, they need to be protected from wind and water erosion by planting appropriate trees such as Casuarina.
- Dystric Arenosols (19,600 ha) have developed on coastal hinterland (upstream to the lagoon system). These soils are provided with a thin organic top layer and better nutrient level than the Luvic Arenosols. However, they are no suitable for crops, except some appropriate trees and shrub which can protect them from erosion.

Other soil types can also be found over the Provinces covering small surfaces such as Gleysols (flooded soils) and Histosols (organic soils).

4.1.5. GROUNDWATER

Groundwater resources are mostly exploited in the coastal plain area (see Table 4.2). The aquifers manly consist of:

- Holocene (contemporaneous) sedimentary rocks (sand and clayey silt) deposited by rivers, lagoons and sea. This aquifer is generally 4 to 30 m thick and the water table is less than 4m deep. The forecast potential reserve from Holocene aquifer amounts to about 666,000 m^3/day.
- Pleistocene formations overlaying the rocks of Da Nang formation. This aquifer is generally 5 to 15 m thick and the water table is from 1 to 2.5 m deep.
- Pleistocene deposits such as gravel, sand and clay. This aquifer is generally 10 to 75 m thick and may supply up to 2,000 m^3 per day. The forecast potential reserve from Pleistocene aquifer amounts to about 395,000 m^3/day.
- Neocene silica gravel, with a thickness of 10 to 100 m
- Karstic limestone formations of the Devonian system, which may supply up to 1,000 m^3 per day. The forecast potential reserve from Devonian aquifer amounts to about 386,000 m^3/day.

Table 4.2: Main features of the exploited ground water resources in the coastal lowland of HTT Province

Region *(water supply subproject)*	**Geologic formations**	**Number of operating wells**	**Average well yield (m^3/day)**	**Current abstraction/ Reserve (m^3/day)**	**Mineralization (g/l)**
Phong Dien, Quang Dien *(HB Chuong, Phong Tu.)*	Holocene, Pleistocene, Neocene, Karstic	15	612	9,185 17,000	0.11 - 1.52
Van Ha, Lai Bang, Tu Ha *(Tu ha.)*	Pleistocene, Karstic	9	620	5,582 20,000	0,11 - 0.66
Thuy Bieu, Luong Quan *(Quang Te)*	Holocene (Huong River)	8	463	3,705 5,000	0.09 - 0.50
Huong Thuy, Phu Vang *(Loc Bon)*	Holocene, Pleistocene	5	1,121	5,608 15,000	0.09 - 0.40

In the vicinity of seashore, salt intrusion may occur and render water quality unsuitable for drinking water production. Quality parameters of groundwater abstracted for drinking

production at Phu Bai Treatment Plant are shown Table 4.3. The analysis indicates an organic contamination which is difficult to explain. On the other hand, as compared with surface water parameters, the ground water is distinguished by lower pH, higher level of dissolved salt and iron and lower bacterial content.

In the mountainous areas, groundwater is abstracted by rural communities by means of 5 to 10 m deep boreholes. Groundwater resource has not been investigated in these areas.

Table 4.3: Quality of groundwater abstracted in Phu Bai for production of potable water

Parameter	Unit	Standard TCVN 09:2008 (*)	Phu Bai Wells (Huong Thuy D.)
Turbidity	NTU	non reg.	1.84
pH		5.5 – 8.5	5.6
COD	mg/l O_2	4	1.38
NO_2^-	mg/l NO_2^-	1	0.02
NH_4^+	mg/l NH_4^+	0.1	0.15
NO_3^-	mg/l	15	3.7
SO_4^{2-}	mg/l	400	7.1
ΣP	mg/l	non reg.	0.69
EC	µS/cm	non reg.	129
TDS	mg/l	1500	64.6
Cl^-	mg/l	250	76.1
DO	mg/l O	non reg.	6.3
Σ iron	mg/l	5	5.19
Al	mg/l	non reg.	0.05
F^-	mg/l	1.0	0.02
Total Coliform	MPN/100ml	3	69
Faecal Coliform	MPN/100ml	non reg.	140

(*) more recent standard for groundwater quality

4.1.6. SURFACE FRESH WATERS

4.1.6.1. Main Water Courses and Catchment Basins

The main river running through the TTH Province is the Huong River, the catchment basin of which covers 2,830 km^2 that is 55% of the Province surface (see Fig. 5). The Huong River originates from the junction of two streams: Ta Trach River and Huu Trach River, which join around 15 km upstream of Hue City and 40 km upstream of the river mouth. The main tributary Ta Trach River originates in the northwest of the Bach Ma range at an altitude of more than 1,700 m. After passing Hue City, the Huong River discharges into the Tam Giang lagoon and finally flows to the sea at the Thuan An mouth, 104 km downstream of the Ta Trach River source.

It should be mentioned that the natural course of the Huong River within Hue City has been diverted and canalized long time ago in order to surround and protect the old city and ancient imperial palace (moats). Within Hue City, the Huong River also received a

small size tributary called Nhu Y River, which crosses the new city and then discharges a lot of pollutants into the Huong River.

In its lower reaches the Huong River received a third main tributary: the Bo River, the basin of which covers 938 km^2 (see Fig. 5)

Out of the Hong River basin, the main watercourses are:

- the O Lau River, which drains the main part of mountainous north-western uplands of Phong Dien District, flows in the vicinity of the city of Phong Dien, follows to the north-west the border of the Quang Tri Province, and then turns to the south-east before discharging into the western end of the lagoon system.
- the Sap River, which drains the western part of the A Luoi District, flows in the vicinity of the city of the city of A Luoi and then flows southward to Laos.

In the south-eastern part of the TTH Province, there are some small size coastal water courses flowing to the lagoons such as Dai Giang River, Nong River and Truoi River, or to the sea such as Bu Lu River.

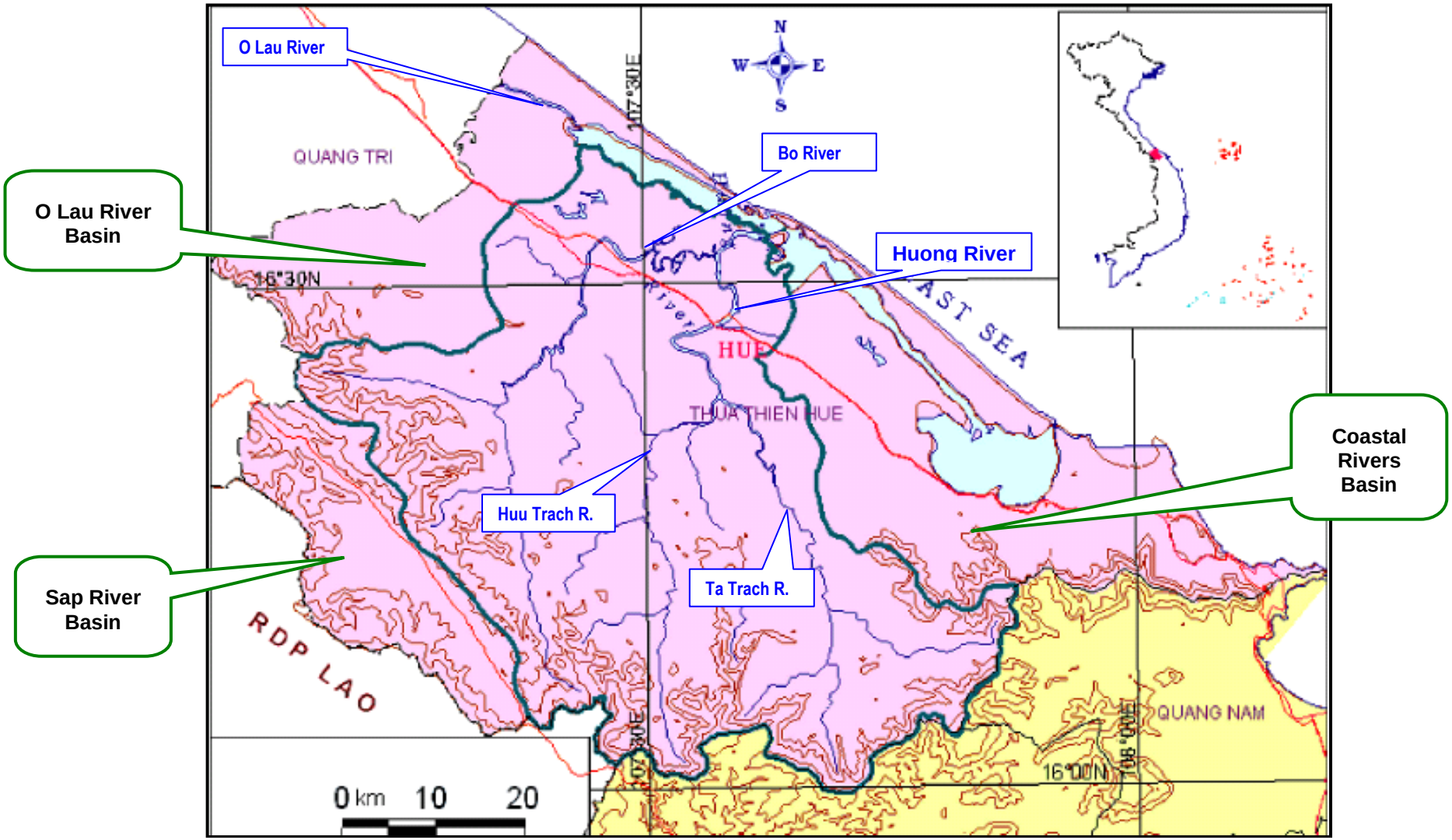


Figure 5: Main rivers and water catchment of the TTH Province (in pink)

4.1.6.2. Waterworks

Four main waterworks are located in the TTH Province, more particularly in the Huong River basin:

- a dam dedicated to hydropower and irrigation has been built on the Huu Trach River in Binh Dien, about 10km upstream of the Ta Trach junction, with a catchment area of 583 km^2. This dam is 54 m high, with a total capacity of 700 million m^3.
- a large, multipurpose dam (irrigation power, flooding control and water supply) is under construction on the Ta Trach River in Dong Hoa about 17 km upstream of the confluence, with a catchment area of 730 km^2 and a gross capacity of 435 Mm^3. This dam will be 55 m high.
- an overflow-like barrage, called Thao Long barrage, has been erected in 2004 across the Huong River in order to prevent the ingress of saline lagoon water into the lower reaches of the River without preventing the river discharge during the flood periods..
- a dam dedicated to hydropower, irrigation and flood protection is being constructed in Co Bi, on the Bo River, about 35 km upstream of the confluence with the Huong River

Doubtless from both hydrological and ecological standpoints, the most impacting of these waterworks will be the Dong Hoa dam on the Ta Trach River. Impact mitigation has been however provided for by a full impact assessment conducted by the Japanese Co-operation.

In addition, TTH Province counts more than 450 dams dedicated to crop irrigation scattered throughout the Province's territory and which supply irrigation water for about 26,000 ha of rice fields.

Table 4.4 Dams and lakes used for irrigation in the TTH Province in 2009 (data from the Department of Agriculture and Rural Development of the TTH Province).

District	Dams	Lakes	Irrigated rice fields area
Phong Dien	85	49	4,492 ha
Quang Dien	68	57	3,822 ha
Huong Tra	80	67	3,090 ha
Hue	5	39	972 ha
Phu Vang	42	77	5,410 ha
Huong Thuy	16	42	3,262 ha
Phu Loc	48	44	3,750 ha
Nam Dong	50	25	356 ha
A Luoi	61	31	770 ha
TOTAL	**455**	**431**	**25,924 ha**

4.1.6.3. Freshwater Lakes

There are more than 430 freshwater lakes in the TTH Province (see above Table ●), most of which have been created by dams (impoundment lake). According to the

Department of Agriculture and Rural Development of the TTH Province, the total volume of water stored in lakes is over 500 million m^3.

4.1.6.4. River Flow

Long term average annual runoff of the Huong River is about 6.25 billion cubic meters or an average flow rate of 71 L/s/km^2 over the entire catchment area. These data have been estimated over the three past decades with an average runoff depth of 2,210 mm. However, the annual flow may vary from nearly 3 billion (1989-90) to nearly 12 billion m^3 (1996-97).

In accordance to the rainfall, the flood season lasts for 4-5 months from September-October to December. Flood volume makes up 70-75% of total annual runoff. The maximum monthly flow usually occurs in November every year. Heavy rainfall and steep slopes in the middle and upper reaches of rivers result in great fluctuations in floods. In the historical flood in November 1999, the flood peak discharge was 5,320m^3/s for the Huu Trach River at Binh Dien, and 14,000m^3/s for the Huong River at Kim Long (Hue City). In the lower reaches, large floods may cause bank collapses in rivers and seacoasts and may create new river mouths.

The flow logically varies together with the rainfall. The low flow period lasts for 7-8 months from January to August-September (see Fig. 6). In the low flow period there are usually small floods, called “tieu man”, in May and June. These are a consequence of the short rainy season which occurs in April and May in the highlands (see § 4.1.2.1). Hence, the period of lowest flow may be in February to April or June to August. The long term minimum monthly runoff usually occurs in July or August. The long term minimum specific discharge of the Huong River is about 0.005-0.010 m^3/s/km^2. In the dry season, long periods of hot weather may result in the river nearly ceasing to flow. This allows salt water to penetrate further up the river resulting in a lack of fresh water for domestic use and for production.

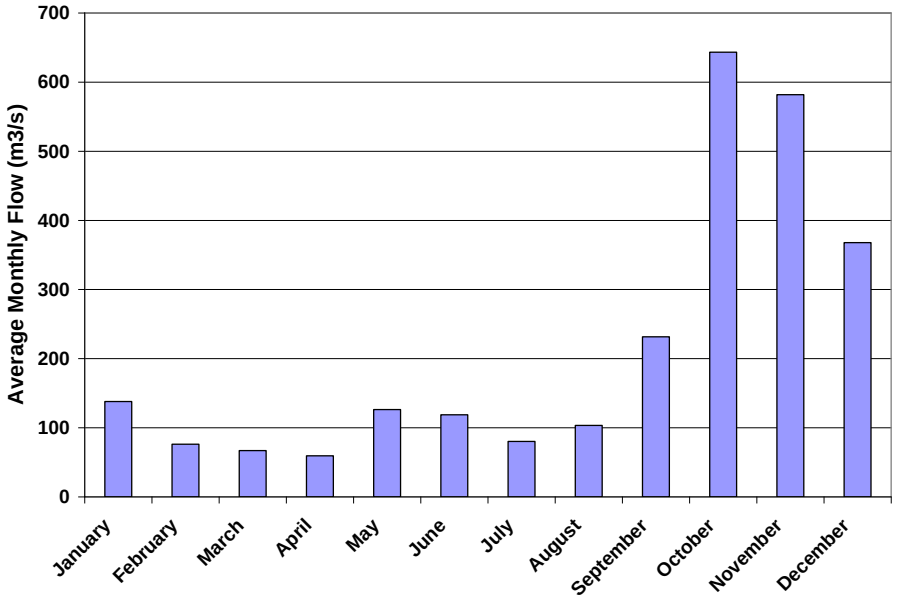


Figure 6: Average monthly flow of the Huong River 1 km upstream of the Thao Long barrage

Other mountain rivers such as Bo River are also subject to flash flood: for example, in 1953 a maximum flow value of 4000 m^3/s was recorded at the Co Bi station on the Bo River.

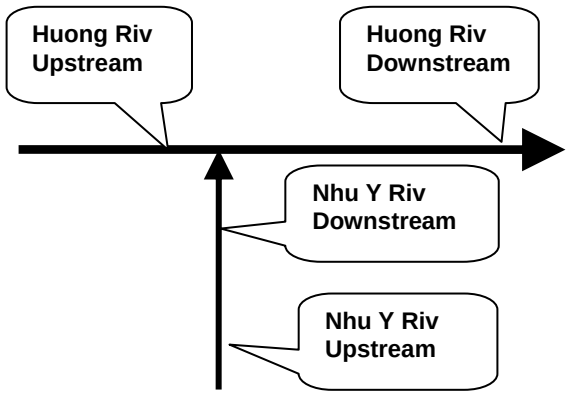
4.1.6.5. River Water Quality and compliance with standards for drinking water production

According to formal reports, the Huong River has appeared so far to be the least polluted of the main Vietnamese rivers (Vietnam Environmental Performance Report, 2005). It could be explained by the high flow, low density of population dwelling in its catchment basin, especially upstream of Hue City, and the moderate development of industrial sector in the urban area as compared to other Vietnamese large cities. Upstream of Hue City, the parameters of Huong river's water quality achieve level "A" (good quality), defined by the Vietnamese regulation on raw water quality for drinking water supply (TCVN 5942 - 1995).

Within Hue City, an important contributor to the Huong River's water pollution is the Nhu Y River, which shows high levels of COD, BOD, dissolved salts and coliforms discharged by the housings and industrial settings of the new city (see Table 4.5). However, due to the dilution of discharged pollutants in the high volume of Huong River waters, the pollution level of the main river is not dramatically increased downstream.

Table 4.5: Quality parameters for the Huong River and its tributary, the Nhu Y River, within Hue City in February - March 2008 (dry season)

Parameter	Standard	Huong River Upstream	Nhu Y River Upstream	Nhu Y River Downstream	Huong River Downstream
pH	6,0-8,5	7.0	7.6	7.1	7.1
Turbidity (NTU)	non reg.	< 1	6.5	6.9	< 1
DO (mgO_2/l)	> 6	6.4	2.0	5.4	6.6
BOD (mgO_2/l)	6	< 1	12	8	2
COD (mgO_2/l)	15	9	38	39	7
PO_4^{3-} (mg/l)	0.2	0.007	0.018	0.032	0.007



Huong River Upstream: Dong Ba market, 0.5 km upstream of confluence

Huong River Downstream: La Y dam, 2.5 km downstream of confluence

Nhu Y River Upstream: Van Dung bridge, 2.5 km upstream of confluence

Huong River Downstream: Vi Da bridge, 0.5 km downstream of confluence

Table 4.6 shows the quality parameters of the main water intakes dedicated to drinking water production within TTH Province.

Table 4.6: Minimum, mean and maximum values of the monthly average concentrations of pollutants at two sites of the Huong River over 2008 (from HUEWACO).

Parameter	Unit	Standard TCVN 08:2008	Van Nien Intake (● km upstream of Hue City centre) *Intake of quang Te subproject*			Dong Ba Market (Hue City centre)		
		Class A2 (*)	Min.	Mean	Max.	Min.	Mean	Max.
Turbidity	NTU	non reg.	1.62	8.12	34.20	0.95	7.07	31.60
pH		6,0-8,5	6.90	7.02	7.28	6.82	7.00	7.38
COD	mg/l O_2	15	0.60	1.05	1.95	0.86	1.50	2.19
NO_2^-	mg/l NO_2^-	0.02	0.01	0.02	0.09	0.01	0.02	0.05
NH_4^+	mg/l NH_4^+	0.2	0.06	0.17	0.26	0.12	0.21	0.41
NO_3^-	mg/l	5	1.92	3.46	4.53	3.02	4.19	5.20
SO_4^{2-}	mg/l	non reg.	0.98	3.35	7.12	2.22	6.14	11.28
PO_4^{3-}	mg/l	0.2	0.18	0.79	2.44	0.27	1.31	4.47
EC	µS/cm	non reg.	36.90	51.53	62.60	38.70	55.04	67.90
TDS	mg/l	30	18.40	25.75	31.30	19.30	27.51	33.90
Cl^-	mg/l	400	5.70	8.02	10.00	7.20	9.36	14.90
DO	mg/l O2	> 6	6.02	6.67	6.90	5.25	6.31	6.80
Σ iron	mg/l	1	0.07	0.26	0.77	0.04	0.21	0.36
Al	mg/l	non reg.	0.01	0.06	0.16	0.00	0.11	0.29
F^-	mg/l	1.5	0.00	0.03	0.06	0.01	0.03	0.09
Faecal Coliform	MPN/ 100ml	5000	430	1331	2400	430	2305	4600
Total Coliform		non reg.	1100	2225	4600	930	4352	11000

(*) Class A2: surface water of quality suitable for water supply with appropriated treatment

Due to the semidiurnal tide regime, with the biggest tide amplitude up to 60-80cm, saltwater goes regularly up-river during the dry season, usually up to Thien Mu Pagoda (5km upstream of the lagoon). The salinity of the lower reaches of Huong River increases gradually from beginning of low flow season and achieves maximum at about August During exceptionally dry years such as 2002, saltwater intrusion occurred up to 30 km inland. More often, significant rise of salinity is observed at the intake of Gia Vien Water Plant that jeopardizes the main drinking water resource of Hue City. To prevent, or at least limit, the saltwater intrusion, an overflow barrage (weir) has been constructed in 2004 across the Huong River in Thao Long, about 1 km upstream of the discharge point into the lagoon. Since then, the operation of the Thao Long barrage seems have diminished the salinity intrusion into the Huong River: during the dry period (February to September) of 2008, the average salinity measured about 500 upstream of the Thao Long barrage have stayed under 0.5 g/l as it was about 7.0-7.5 g/l 500 m downstream. However, only a long term measurement series including extreme high and low water events will confirm the effectiveness of this waterworks as a "salt barrier".

Table 4.7: Quality parameters of surface water at some intakes for drinking water production out of Hue City during wet and dry season (when the river name is in italic, the intake is undertaken in small tributaries)

Item	Unit	Standard TCVN 08:2008	Truoi River At Loc Tri (Phu Loc D.)	Ta Trach river at Khe Tre (Nam Dong D.)		Bo River at Tu Ha (Huong Tra D.)		Huu Trach Riv. at Binh Thanh (Huong Tra D.)		Nong River at Loc Bon (Phu Loc D.)		Thuy Binh Riv. at Chan May (Phu Loc D.)		Cau Hai Riv. at Bach Ma (Phu Loc D.)		O Lau Riv. at Hoa Binh Chuong (Phong Dien D.)	
			Loc Tri subproject	*Nam Dong subproject*		*Tu ha subproject*		*Binh Thanh subproject*		*Loc Bon subproject*		*Chan May subproject*		*Out of project*		*H.B. Chong subproject*	
		Class A2 (*)	Wet	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Turbidity	NTU	non reg.	4.49	2.41	2.51	8.03	8.31	10.46	6.48	2.00	1.85	0.99	1.40	1.16	0.75	5.01	19.26
pH		6,0-8,5	7.1	6.9	6.9	6.6	6.7	7.1	6.9	7.0	6.9	6.8	6.9	6.9	6.8	7.03	9.01
COD	mg/l O_2	15	0.60	0.88	0.85	1.2	1.18	1.46	1.63	1.01	0.90	0.88	1.15	0.84	0.90	1.67	1.33
NO_2^-	mg/l NO_2^-	0.02	0.018	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
NH_4^+	mg/l NH_4^+	0.2	0.09	0.12	0.1	0.19	0.15	0.14	0.22	0.10	0.12	0.08	0.10	0.10	0.09	0.19	0.20
NO_3^-	mg/l	5	0.34	2.9	3.2	3.7	3.8	3.8	4.0	3.2	3.6	3.4	3.4	3.1	3.3	4.60	3.63
SO_4^{2-}	mg/l	non reg.	3.81	5.0	4.3	7.9	6.0	5.6	4.3	4.5	3.9	3.8	3.7	3.4	3.0	6.01	7.04
PO_4^{3-}	mg/l	0.2	0.1	0.39	0.78	0.84	1.15	1.7	5.7	0.41	0.65	0.33	1.5	0.33	0.66	0.74	0.37
EC	µS/cm	non reg.	39.6	44	37	52	47	49	40	43	39	23	27	20	22	46	50
TDS	mg/l	30	19.8	22.3	18.5	27.1	23.4	24.3	19.2	23.4	19.5	11.6	13.3	10.9	11.0	23.2	26.0
Cl^-	mg/l	400	12.25	8.7	7.3	11.1	8.8	10.5	7.6	9.5	7.3	7.3	6.4	6.8	4.8	10.2	15.0
DO	mg/l O	> 6		6.7	6.8	6.6	6.8	7.0	9.3	6.4	6.8	6.7	6.8	6.8	6.9	6.6	6.4
Σ iron	mg/l	1	0.49	0.22	0.15	0.75	0.44	0.36	0.20	0.29	0.22	0.15	0.16	0.14	0.19	0.40	0.64
Al	mg/l	non reg.	0.009	0.1	0.1	0.05	0.13	0.07	0.10	0.09	0.09	0.13	0.11	0.05	0.07	0.09	0.05
F^-	mg/l	1.5		0.10	0.04	0.03	0.04	0.03	0.04	0.03	0.02	0.06	0.05	0.04	0.03	0.03	0.02
Total Coliform	MPN/100ml	5000	930	2400	2208	2162	2269	2392	387	1902	2096	1850	420	1732	1800	3133	2400
Faecal Coliform	MPN/100ml	non reg.	90	1500	998	1281	1189	1261	670	841	759	584	797	625	459	1467	1518

(*) Class A2: surface water of quality suitable for water supply with appropriated treatment

:

Quality standards for water used for drinking water production have been modified several times for the last 15 years: the Surface Water Quality Standard (TCVN 5942:1995), which was enacted in 1995 and revised in 2001, was applied until 31 December 2008 and then revised to QCVN 08:2008. The current regulation (QCVN 08:2008) is based on standard values for 32 parameters and establishes four classes of surface waters:

- A1: suitable for domestic water supply (can be delivered with only disinfection
- A2: suitable for domestic water supply, but adequate treatment technology must be applied
- B1: good for irrigation or other purposes demanding similar quality level.
- B2: good for water transportation and other purposes not demanding for high-quality water

This four-class classification replaces the simpler two-class classification (A: suitable for water supply with adequate treatment and B: suitable for other uses) established by the TCVN 5942:1995. The new standards are not very more stringent than the older ones but more detailed, especially as regards the pesticides: 10 insecticides and 3 herbicides should be individually measured. Furthermore, the new standard regulates the *Escherichia coli* concentration in addition to the total coliform concentration.

As shown in Table 4.6 and 4.7, the water quality parameters of rivers used for the production of drinking water by the current and the future WTPs involved in the Project are compliant with the up-dated Vietnamese standards (QCVN 08:2008) except for phosphate concentration. Phosphorus does not constitute a health concern per se but may foster the growth of algae (eutrophication) in water storage system (tanks and reservoirs). Since algae may cause release of toxic or harmful substances into stored water, higher injection of chlorine are often required to eliminate algae. Actually, high phosphate levels measured in Huong river, particularly when crossing Hue City, associated with rather high level of ammonia and nitrite can explain frequent occurrence of algal blooms leading to the dark green color that features the eutrophic water.

Table 4.6 and 4.7 show that the excess of phosphorus (against the standard) occurs in almost all rivers but that the levels are lower in small streams or in upstream stretches of large rivers and that the level are almost always higher in dry season. These observations support that the agricultural fertilization plays a prevailing role in the rise of phosphorus content in river water.

It is noteworthy that no pesticide is measured by HUEWACO in the raw waters, but that activated carbon is used for treating river waters abstracted downstream of intensive agricultural areas, i.e. in Tu Ha WTP and Hoa Binh Chuong. However the impact of agriculture on the river water quality strongly suggested by the phosphorus should prompt to monitor pesticides regularly in all rivers used by HUEWACO. Heavy metals are only monitored every 6 months but the lack of emission sources (industrial facilities) upstream of the intake, this frequency seems to be relevant.

The main rivers used for drinking water production in the subproject are featured and shown in Table 4.8 and 4.9.

Table 4.8: Features of rivers used for water production

Water Supply subproject	Raw Water Source (River)	Flow	Turbidity
Hoa Binh Chuong	O Lau River (downstream stretch)	high	moderate
Phong Tu	O Lau River (middle stretch)	high	moderate
Quang Te	Huong River	very high	high
Tu Ha	Bo River (downstream tributary of Huong Riv.)	high	moderate
Bin Thanh	Huu Trach River (middle tributary of Huong Riv.)	high	moderate
Loc Bon	Nong River	medium	clear water
Loc An	Truoi River	medium	clear water
Loc Tri	Khe Su River	low	clear water
Chan May	Unnamed small stream	medium	clear water
Nam Dong	Khe Tre River (upstream tributary of Huong Riv.)	medium	clear water
A Luoi	Unnamed small torrent	low	clear water

Table 4.9a: Pictures of rivers used for water production

Huong River (Quang Te subproject)

Bo River (Tu Ha subproject)

O Lau River (Hoa Binh Chong intake)

O Lau River (future Phong Tu intake)

Table 4.9b: Pictures of rivers used for water production (continuing)

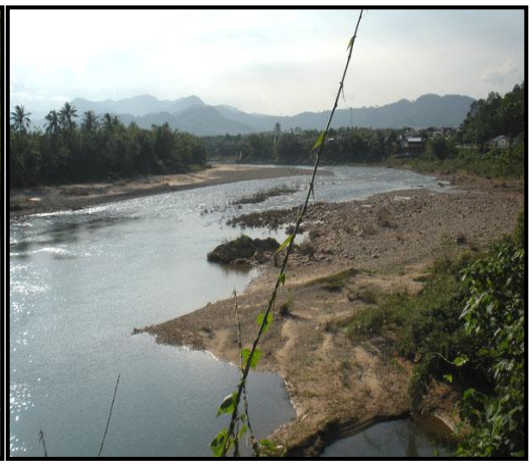
Huu Trach River (Binh Thanh intake)

Nong River (future Loc Bon intake)

Truoi River (Loc An subproject)

Khe Su River (Loc Tri subproject)

Small torrent (A Luoi intake)



Khe tre (Nam Dong intake)

4.1.7. COASTAL AND SEA WATERS

4.1.7.1. The lagoon complex and its protecting sand barrier

With a length of 68 km and a surface area of 220,000 ha (220 km^2), the Tam Giang-Cau Hai lagoon complex occupies 4.3% of the TTH Province and is the largest lagoon of South-East Asia. It comprises a series of connected lagoons situated to the north and east of Hue city which are named successively from the north-west to the south-east (see above § 4.1.6, Fig. 5).

- Tam Giang Lagoon, which receives the O Lau River (on its western end) and the Huong River (on its eastern end). This lagoon is connected to the sea via the Tu Hien channel, by which the Huong River flows into the sea ("Huong River estuary"). Actually, the Huong River's flow has to cross the lagoon from the mouth, on the south bank, to the channel, so a part of the river flow is likely to be diverted into the lagoon.
- Thanh Lam Lagoon, comprising the Sam Swamp and the An Truyen Swamp, located to the north of Hue City and not open to the sea
- Thuy Tu Lagoon, a narrow piece of water (nearly 500 m at the south-eastern end), not connected to the sea
- Cau Hai Lagoon, the largest lagoon (7 x 10 km) which is connected to the sea by the Tu Hien channel, the south bank of which harbors a seaport. This lagoon receives the flows of many coastal rivers.

The lagoons are separated from the sea by a long and, at some places, narrow sand dune system. As mentioned above, the lagoon complex discharges to the sea through two narrow tidal inlets, Thuan An inlet and Tu Hien inlet, which have been channeled in order to stabilize them (in the past times these outlets were sometimes closed or opened are different places according to the surge). Consequently, the system is influenced by both, marine (waves and tides) and inland flow (siltation and sedimentation) conditions. Interactions of the tides and salt water from the sea with inland flow discharges of the six main rivers cause highly dynamic characteristics of its hydraulic and morphological behavior.

Actually, the coastal sand dune barrier, providing protection for the lagoon, is exposed to frequent attack both by flooding from the rivers and by surges and waves from the East Sea. The attack poses a serious annual breaching threat to the lagoon barrier, which was damaged several times in the past, especially under tropical cyclone conditions. For example, during the cyclone EVE in November 1999 which caused the worst flooding ever recorded in 50 years (cf. § 4.1.2.2), the lagoon barrier was broken at six different sections. Among those the breach at Hoa Duan commune was the largest with the final width of about 700 m and depth of 5-9 m.

4.1.7.2. Coastal seawaters

Although the coastline of TTH Province is only 120k m in length, the tide regime shows a very complicated evolution. To the north, from the limit of Quang Tri Province to the Thuan An channel, the tidal regime is irregular semidiurnal form, almost all the days in month semidiurnal tide with average magnitude from 1.2 to 1.6 m, decreasing to the south. In the vicinity of Thuan Anh channel, the sea is subject to a regular semidiurnal regime (two high tides and two low tides per day). Tide fluctuation here is the smallest observed on the whole Vietnamese coast, with a daily amplitude from 30 to 50 cm at Thuan An channel. In the vicinity of Tu Hien channel, the amplitude is higher, but stays between 55 and 100 cm. In the south-eastern area, the tide changes into diurnal regime with 20-25 days of diurnal tide/month, and a fluctuation amplitude of 80 cm in springtide. In the vicinity of Chan May Bay, the amplitude varies from 20 to 145 cm, with an average value of 70 cm.

Along the coast of TTH Province, the tidal current has irregular semidiurnal and regular diurnal features, but is regular semidiurnal in the vicinity of Thuan An Channel. The fully diurnal and semidiurnal tide currents have the same level in Thuan An Channel, that is from 15 to 20 cm/s. Going further into Tam Giang Lagoon, the fully diurnal is only 3cm/s, while the semidiurnal tide current comes up to 25–30 cm/s. In Tu Hien Channel, the semidiurnal tide current achieves 35-40 cm/s as in Chan May Bay, the maximum tide current only achieves from 12 to 22 cm/s.

The wave regime is affected by monsoon regime. In winter, in the coastal area, the wave of north and north-east directions prevails. At Thuan An channel, the wave of north-east direction has frequency of 99% and the height from 0.25 to 3m. In summer the wave direction is mainly south-west and south-east in the open sea, south-east in coastal area. In the vicinity of Thuan An channel, the wave of east direction with the height from 0.2 to 1.0 m has frequency of 99%.

The wave direction is relatively stable along the coast with season. In summer, the wave current directs from the south coast upward (SE–NW), in winter, the current goes to the opposite direction (NW–SE). The wave current speed fluctuates from 30 to 100 cm/s and achieves the greatest value in the monsoon season.

4.1.8. AIR QUALITY

Air quality is monitored within Hue City at 3 urban sites i.e.: Dong Ba market, Thach Han street (old city) and Thuan Hoa ward (old city park) and at 2 industrial sites i.e.: Chan May economic park and Phu Bai industrial park. The monitored parameters are dust, carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and lead (Pb).

Average dust concentrations are comprised between 180 and 440 µg/m^3 and in urban sites and between 20 and 320 µg/m^3 in industrial sites (2005-2007 values reported by the Environment Department of TTH Province). By "dust" it is meant Total Suspended Particulate (TSP), that are mainly comprised in terms of weight of re-suspended soil particles. Because these very coarse particles do not deeply enter the respiratory tract and hence are not really of health concern, this parameter is no longer monitored in many countries, where only particles less than 10 µm (PM_{10}) or even smaller size ($PM_{2.5}$) are subject to regulation by public health and environmental authorities (including international agencies like WHO).

Average CO concentrations are comprised between 2800 and 9100 µg/m^3 and in urban sites and between 3000 and 6500 µg/m^3 in industrial sites, these values being below the national long-term standard of 10 000 µg/m^3 (TCVN 5937:2005).

Average SO_2 concentrations are comprised between 8 and 49 µg/m^3 and in urban sites and between 7 and 33µg/m^3 in industrial sites, these values being below the national long-term standard of 50 µg/m^3 (TCVN 5937:2005).

Average NO_2 concentrations are comprised between 10 and 54 µg/m^3 and in urban sites and between 11 and 26 µg/m^3 in industrial sites. Thus some urban concentrations are slightly over the national long-term standard of 40 µg/m^3 (TCVN 5937:2005).

Average Pb concentrations are comprised between 2 and 3 µg/m^3 and in urban sites and between 1 and 4 µg/m^3 in industrial sites. These values are markedly above the national long-term standard of 0.5 µg/m^3 (TCVN 5937:2005), which is difficult to explain because the gasoline is unleaded since many years. More information about the protocol and detection level of Pb analysis in air would be needed to confirm if Pb air concentration is a real concern.

Outside Hue District, the air quality is expected to be good due to the lack of significant air pollution sources. It is noteworthy that the high frequency of rainy days should contribute to the abatement of air pollution, especially as regards long term exposure.

4.1.9. NOISE LEVEL

Noise level are monitored in a busy urban, commercial area (Dong Ba ward), a quiet urban area (Thuan Hoa ward) and at 2 industrial parks (Chan May-Lang Co and Phu Bai industrial parks). As expected, the most elevated noise level is observed in the busy urban area, where maximum values vary from 71 to 85 dBA and median values from 68 to 77 dBA (2005-2007 values of the Department of Environment of TTH Province). The lowest levels have been measured in industrial parks (max from 43 to 75 dBA, median from 38 to 62 dBA). The transport sector (trucks, cars, motorbikes) is indubitably the main source of noise. It is worth nothing that the Vietnamese standard is of 70 dBA in day time and 50 dBA in night time for commercial areas and respectively 60 and 45 dBA in residential areas (TCVN 5949:1998). These standards are very likely exceeded in central Hue city.

4.2. ECOLOGICAL RESOURCES

4.2.1. ECOSYSTEMS AND BIODIVERSITY

In an only 5,051km^2 large territory, the TTH Province harbors a series of very diverse landscapes, from the high mountainous uplands down to huge lagoons, sand dunes and seashore, and even more ecological habitats. In terms of biodiversity, three main ecological areas are usually distinguished by the specialists:

- the mountainous "Green Belt" comprising the Phong Dien Nature Reserve (415 km^2), the Bach Ma National Park (223 km^2) and the woody mountain range which connects these protected areas (in total 1340 km^2)
- the Cau Hai–Tam Giang lagoon complex, which is the larger lagoon of South-East Asia (220 km^2)
- the Son Tra–Hai Van coral reef formation, which is the third Vietnamese site in terms of marine biodiversity (70 km^2)

Moreover, the role of rivers, forming a very dense network which connects the mountainous ecosystems to the coastal ones and provides the latter with essential inputs such as nutriments, seeds and juveniles, cannot be overlooked.

4.2.2. TERRESTRIAL BIODIVERSITY

The mountain and lowland rain forests of TTH Province (Green Belt) make up a large part of the Central Annamites sub-ecoregion which support a number of species found nowhere else in the world such as the Saola *Pseudoryx nghetinhensis*, discovered in 1992, Edward's Pheasant *Lophura edwardsi*, Annamite Striped Rabbit *Nesolagus timminsi* and the Annam Partridge *Arborophila merlini*, as well as the Asian elephant *Elaphas maximus* and tiger *Panthera tigris*. It supports also threatened species as listed by IUCN (2000) including tiger (Critically Endangered), Saola (Endangered), Edward's Pheasant, Douc Langur *Pygathrix nemaeus* (Endangered), Annam Partridge, Annamite Striped Rabbit, White-cheeked Gibbon *Hylobates leucogenys*, Truong Son Muntjac *Muntiacus truongsonensis*, Large-antlered (Giant) Muntjac *Muntiacus vuquangensi*. It is noteworthy that many of these species have been too recently identified for their conservation status to be determined sufficiently.

Since the area supports all of the recently described species found in the Greater Annamites ecoregion, it is highly likely to support many other species still to be discovered and studied. This not only applies to mammal fauna because the area is also considered as very rich in forest birds, reptiles and insect. For instance, studies carried out in the adjacent rainforest of Quang Nam District (same ecological features as TTH province) identified 272 bird species, 48 reptile species (snake, lizards and turtles), 34 amphibian species and 194 butterfly species. Many of these species are endemic or/and

threatened. Within the TTH Province, an ecological sampling campaign has been performed in 2003 along the course of the upper and medium valley of Ta Trach River for the purpose of the environmental impact assessment (EIA) of the Dong Hoa dam (see § 4.1.6.2) with the support of BJIC. This campaign has inventoried 156 insect species, 8 amphibian species, 13 reptilian species, 126 bird species and 29 mammal species. The inventory showed six species listed in the Red data Book of Vietnam and six listed in the red List of IUCN, among which the Eurasian otter (*Lutra lutra*) and five bat species.

The richness of flora is also very high in these rain forests: a total of 1,129 species of plant in 164 families have been identified. Since 1996, in the Green Corridor area (TTH Province) eight new butterfly and nine orchid species have been discovered. The sampling campaign for the EIA of Dong Hoa dam (see above) identified 465 plant species (128 families) among which 7 species were listed in the Red Data Book of Vietnam and/or Red List of IUCN.

4.2.3. BIODIVERSITY OF RIVERS, WETLANDS AND LAGOONS

Environmental impact study carried out in 2003 with the support of JBIC for the construction of the Dong Hoa dam on the Ta Trach River provided detailed and quite exhaustive data on the organisms leaving inside this river which could be deemed representative of all large watercourses of TTH province. A total of 46 fish species forming part of 26 families and 8 orders were identified in the river from upstream to downstream. More than 50% of the identified fish species inhabit fresh water, the remaining leaving preferably in brackish water (downstream stretch). Five fish species are registered in the Red Data Book of Vietnam because being vulnerable or rare such as the Giant mottle eel, sampled upstream of the future reservoir.

Animal and vegetal biodiversity of Tam Giang - Cau Hai lagoon complex has been thoroughly studied, especially through the IMOLA project (Integrated Management of Lagoon Activities, supported by Italy). The lagoon complex comprises 7 types of sub-ecosystem: estuarine sub-ecosystem (river mouths inhabited by waterfowls) bordered by agricultural sub-ecosystems (rice fields), water grass sub-ecosystem (50% of total surface, primary production and main habitats for juvenile fish, shrimps and crabs), sub-ecosystem of soft-bottom (30% of the total surface, habitat for small mollusks, crustacean, echinodermata, polychaeta which are prayed on by many fishes) and tidal sub-ecosystem (with lower biodiversity), and mangrove sub-ecosystems (small area mainly occupied by *Avicennia mariana*, *Rhizophora apiculata*, and *Bruguiera sexangula*).

Recent surveys (2006) suggest that about 1000 animal and vegetal species leave in the Tam Giang - Cau Hai lagoon, which can be divided as follows:

- fauna: 72 species of zooplankton organisms, 193 species of benthos organisms (mollusks, crustaceans, worms and so on), 230 fish species, 73 bird species
- flora: 287 species of phytoplankton organisms, 46 seaweed species (algae), 31 higher plant species (not including sea grass), 7 sea grass species and more than 50 unidentified small bottom plant species

From an ecological standpoint, the Tam Giang - Cau Hai lagoon is one of the richest wetland of Vietnam, and also one of the most studied. The outstanding species richness of the lagoon would be due to the complex environmental change it experience periodically over the year. Salinity change between rainy and dry season would be one of the main driver of the biodiversity.

4.2.4. BIODIVERSITY OF COASTAL WATERS

At the south-eastern limit of the TTH Province Son Tra - Hai Van site is the third richest place for marine biodiversity of Vietnam. It harbors 140 coral species (63 genera and 21 families) which cover very densely the sea bottom. Other animal species such as mollusks, crustaceans, echinoderms and sea turtles are very diverse and abundant in this place which have been proposed as a marine protected area (see below § 4.2.5).

4.2.5. PROTECTED AREAS

The network of protected areas is already well developed in TTH Province but is likely to extend significantly in the short and medium term with establishment of new Special Use Forests and marine protected areas.

Currently, three protected areas are registered by UICN in the TTH Province:

- **Bach Ma National Park** (UICN Cat. II), 22,031 hectares (ha, according to UICN) decreed in 1991. This NP is located in the south-eastern part of the TTH Province, along the border of the Da Nang Province, on the territories of Nam Dong and Phu Loc Districts.
- **Phong Dien Nature Reserve** (UICN Cat. I), 41,548 ha, decreed in 2000. This reserve is located in north-western part of the province, along the border of Quang Tri Province, in the Phong Dien District
- **Bac Hai Van Landscape Protection Site** (UICN Cat. III), 10,850 ha, decreed in 1994. This protected site is located between the Bach Ma NP and the sea coast, along the border of the Da Nang Province, in the territory of Phu Loc District.

A **Green Corridor** of 134,000 ha stretching between Bach Ma NP and Phong Dien NR was established in 2004 by the WWF with the support of the World Bank and Dutch Government. This Corridor comprises 11 communes on three District (A Luoi, Nam Dong and Huong Thuy). As a result of regional biological assessments this forest area has been identified as one of the highest conservation priorities in Vietnam. It is actually one of the last remaining lowland wet evergreen forests and also includes some of the longest remaining stretches of Lowland River, within intact forest habitat, in Vietnam. This Corridor supports populations of threatened species such as Saola, Truong Song muntjac, Edwards pheasant, red-shanked douc langur and white-cheecked gibbon. The four-year (2004-2008) Green Corridor project has developed four strategic activities: (i) strengthening conservation and illegal activity prevention, (ii) forest landscape restoration and supporting local communities, (iii) capacity building and awareness raising, and (iv) forest landscape monitoring and evaluation. At present the project has been completed but most of the activities it has initiated and supported are still being developed, especially those which aim to nature conservation and improvement of community livelihood conditions.

It is worth noting that one of the five pilot sites of the **Biodiversity Corridor Initiative** (BCI) supported by ADB, namely the Ngoc Linh–Xe Sap corridor, is focused on Quang Nam Province but also includes the bordering areas of TTH Province, more specifically the area west of the HCMH in A Luoi district. As a result, connections of conservation between Xe Sap area, Phong Dien NP and Bach Ma NP will be secured in the medium term. This conservation project was initiated in 2005 and is planned for completion by 2014.

Another Special Use Forest is the Historical and Cultural Forest Southwest of Hue. This 1260 ha wide area comprising patches of wood land is mentioned as a protected area in some documents but is not inventoried by the IUCN.

The proposed protected areas not yet officially established comprise both forest and lagoon/marine areas as follows:

- the **proposed Soala Reserve** stretches on about 12,000 ha in the southern limit of the TTH Province (on the borders of Lao PDR and Quang Nam Province, in nam Dong and A Luoi Districts) within the existing Green Corridor area. This high mountainous, woody area will be mostly devoted to the protection of Saola (*Pseudoryx nghetinhensis*)
- the **Tam Giang-Cau Hai proposed marine (or wetland) protected area** covers about 25,000 ha and is centred on the Tam Giang-Cau Hai lagoon complex which includes vegetated wetlands (marshes), non vegetated wetlands (mudflats and sandflats), permanently submerged wetlands and man made wetlands (aquaculture ponds). This area has been proposed as protected area since more than 10 years

ago but the protection status and the type of area (marine or wetland) has not been clearly stated. However, it is obvious that such a system harbouring a very rich freshwater/marine biodiversity, sheltering so many waterfowls and providing important spawning, feeding and nursery ground for fish and shellfish on which depends the livelihood of local population needs to be protected.

- the **Son Cha-Hai Van proposed Marine Reserve** covers 6,000–7,000 ha located south of Phu Long District. This protected area comprising the Son Tra isle, the Lang Co Lagoon and the cape of Hai Van Pass, is featured by specific ecosystems of coral reefs and seagrass. The ecological interest of this reserve is enhanced by the juxtaposition with terrestrial protected areas (Bach Ma NP and Bac Hai Van Landscape Protection Site) which enable a physical continuity between the diverse ecosystems.

In addition to these formal protected areas, there is a large number of extensive areas and smaller patches of forest designated as watershed protection forests (including watershed, coastal and wind protection forests).

Table 4.10 and Fig. 7 show the location of subprojects in relation to existing protected areas.

Table 4.10 Water supply subproject and protected areas

Water Supply subproject	Distance from protected areas (PA)	Remarks
Hoa B. Chuong	Far away from any PA	-
Phong Tu	Far away from any PA	-
Quang Te	Near the Historical and Cultural Forest Southwest of Hue	No influence expected on the site
Tu Ha	Far away from any PA	-
Bin Thanh	Far away from any PA	-
Loc Bon	Far away from any PA	-
Loc An	Within the buffer zone of Bach Ma National Park	No influence expected on the site
Loc Tri	Water intake and raw water pipe within the Bach Ma NP administrative/tourist zone), WTP and the treated pipe network within the buffer zone	No influence expected on strict preservation area of the Park
Chan May	Near the Bac Hai Van landscape protection site	No influence expected on the Park
Nam Dong	Within the WWF “Green Corridor”	Infrastructures build in residential areas
A Luoi	Near the Phong Dien Reserve (downstream) and within the WWF “Green Corridor”	Infrastructures build in residential areas

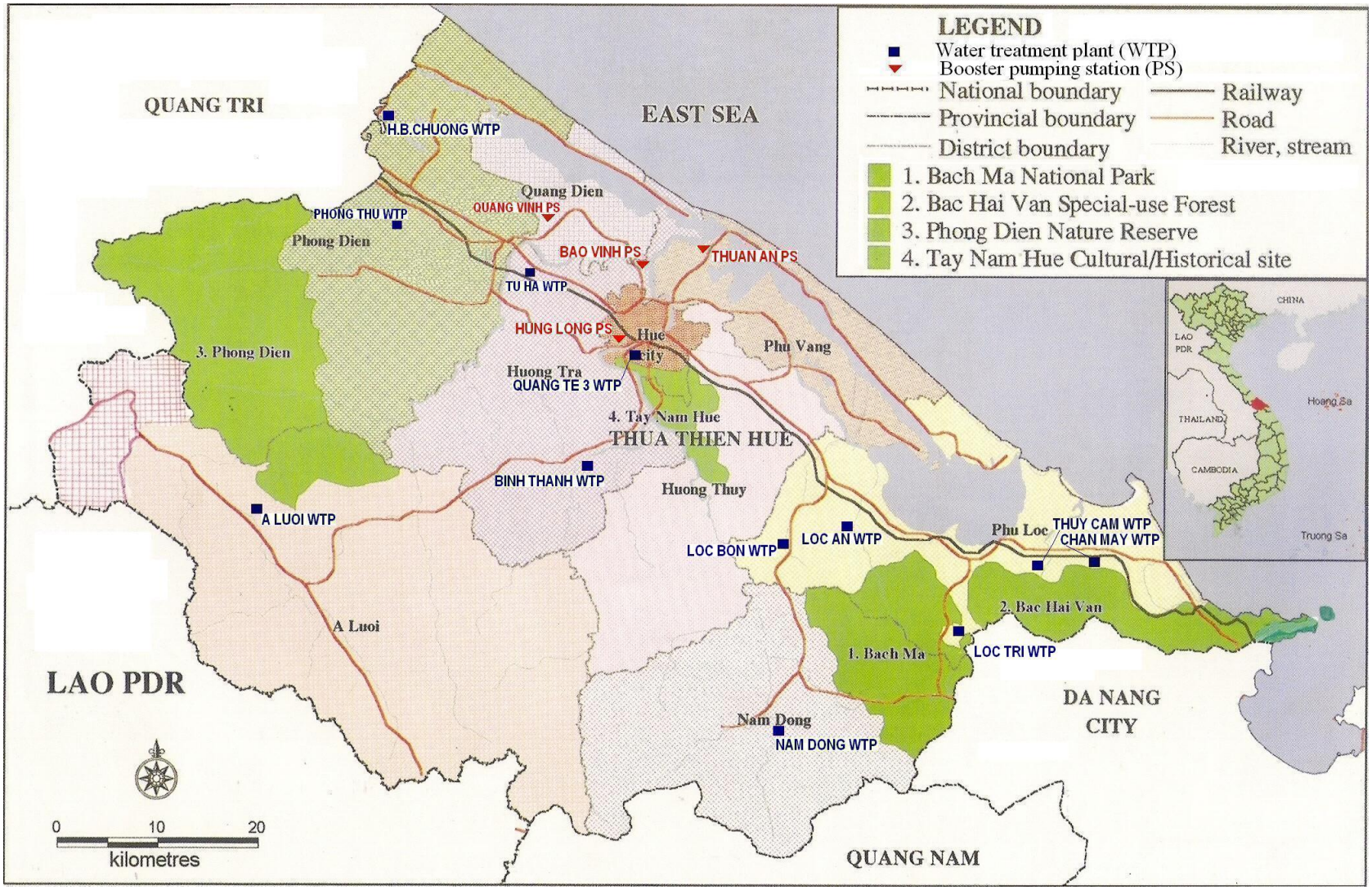


Figure 7: **Location of Drinking Water Treatment Plants of the Project in relation to themain protected areas of the TTH Province (Thy cam WTP is out of Project)**

Actually, two protected areas are likely to be affected by the Project, namely:

- the existing Bach Ma NP, within which a new water intake station and treatment plant will be set up (Loc Tri subproject, see Fig. 7) and
- the proposed Tam Giang-Cau Hai marine protected area, this complex lagoon being fed by most of the of rivers exploited for raw water abstraction (O Lau River, Bo River, Huong River and smaller rivers) and into which the drinking water treatment sludge are discharged.

Features of Tam Giang and Cau Hai Lagoon are described in several chapters of this report (see § 4.1.7.1 and 4.2.3), further relevant information about Bach Ma National Parks are given hereafter.

First it should be remembered that in Vietnam the management of a National Park such as Bach Ma NP mainly aims at:

- maintaining, in a natural state, representative examples of ecosystems, biotic communities, species and genetic resources and to provide ecological stability and diversity
- protecting natural and scenic areas of national and international significance for spiritual, scientific, educational, recreational or ecotourism purposes
- conducting scientific research in ecology, biology and conservation
- controlling the use by visitors for inspirational, educational, cultural, recreational and ecotourism purposes (low impact activities)so as to preserve the area in its natural state
- eliminating and thereafter preventing human activities non compliant with to the purposes of a national park.

Residential and agricultural land cannot excess 5% of the total surface of National Parks.

National Parks can be managed by the provincial authorities but the Bach Ma NP is placed under the responsibility of the Ministry of Agriculture and Rural Development (MARD).

Flora of Bach Ma encompasses more than 1,400 species, i.e. 19% of all flora species present in Vietnam on only 0.07% total of national surface area. As the Bach Ma NP shows typical flora of three bio-geographical areas: Sino-Himalayan, Indo-Burmese, and Malaysian, it is recognized as a site of high biodiversity interest in Indochina area. In terms of remarkable fauna, the Bach Ma NP is of highest interest for the protection of primates like red-shanked douc langur (*Pygathrix nemaeus*) and white-cheecked gibbon (*Hylobates leucogenis*). Tigers have also been identified in the park..

Ecotourist potential of Bach Ma NP is also outstanding. The park offers a steep, winding and very scenic climb up to the top of the mountain range. At the top of the mountain there are a variety of attractions, including hikes, visit to the ruins of the old French chalets. The misty mountain peak is an idyllic setting and there are a number of lodges and restaurants, some of which have recently been renovated. Medium term plans include enlarging the attractions and services offered in the park. For the last pas decade, the visits to the park have averaged nearly 25,000.

Consisting of core protection, ecological (forest) restoration and administrative/tourism zones (see Fig. 8), the Bach Ma NP is surrounded by a large buffer zone which was recently extended to a surface of 21,300ha including 17 communes of TTH Province, Quang Nam Province and Da Nang City (Phu Loc town, Loc An, Loc Dien, Xuan Loc, Loc Hoa, Loc Tri, Khe Tre town, Huong Phu, Huong Loc, Thuong Lo, Thuong Nhat, Thuong Long, Ta Lu, Song Kon, Ting Tu (Quang Nam Province), Hoa Bac (Da Nang city). The buffer zone counts more than 25,000 households (nearly 80,000 people in 2006), most of them being Kinh people (84%) and KaTu people (15%).

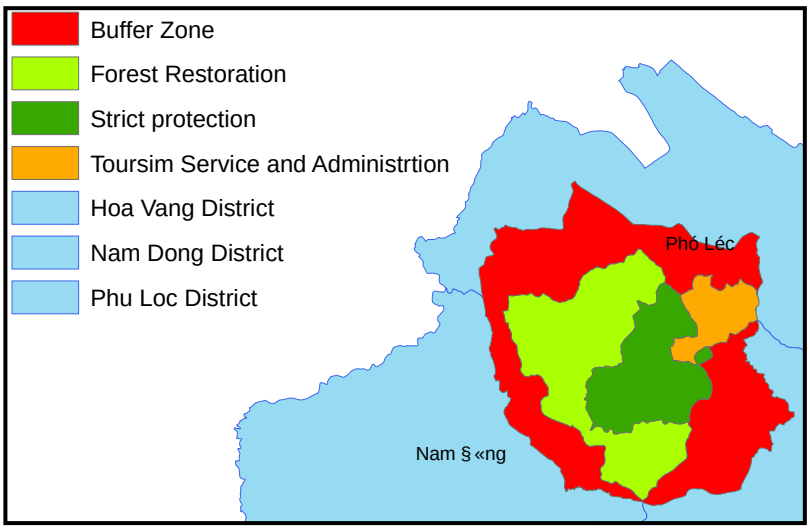


Figure 8: Zoning of the Bach Ma National Park (source: WWF 2007)

Until now, the main works that has affected the Bach Ma NP is the construction of a dam on the Ha Truoi River, completed in 2003, just on the limit of the park. The Ha Truoi Dam is 60 metres high and has a useful storage of 73 million m^3 and a dead storage of 4 million m^3. The dam is expected to provide irrigated water supply to more than 8,500 ha and have a life of 40–50 years. The reservoir drains an area of 7,330 ha, more than 400 ha of which is flooded at high-water level. The flooded area is located in ecological restoration zone. The remaining land of watershed comprises 4000 ha of ecological restoration zone, 2700 ha of core protection zone and about 200 ha of administrative zone.

As regards the Loc Tri subproject, it is worth noting that, as shown by Fig. 9, only the water intake and the raw water pipe will be located inside the core territory, but in the zone dedicated to administrative and tourist activities (orange zone of Fig 8)

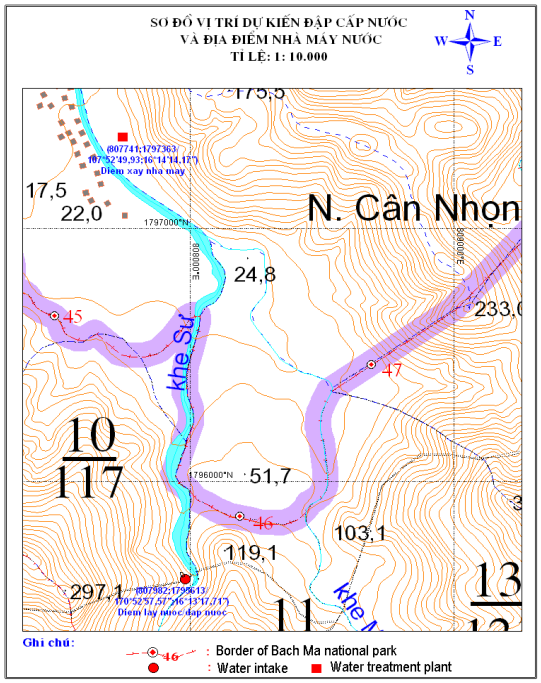


Figure 9: Location of Loc Tri Water intake and WTP within the Bach Ma national Park. The purple line is limit between the core territory in the south and the buffer zone in the north

4.2.6. THREATS TO BIODIVERSITY

In terrestrial ecosystems, an more particularly in forest zones west and south of TTH Province (out of protected areas), the main threats to biodiversity are mainly: (i) loss of forest habitat from forest clearance and encroachment by populations for agricultural and settlement purposes, these activities often causing forest fires, (ii) unsustainable extraction of plants and animals for local consumption and the wildlife trade, which still shows an high demand for endemic, rare species. Implementation of development projects such as road construction. The main objective of the Green Corridor project was to tackle the above mentioned threats and their underlying root causes by working with the local communities and establishing a better partnership between communities and authorities. The strategies developed in this framework have resulted in conservation-oriented land planning, improved land use management plans enabling protection from encroachment by new settlers, educational and awareness-based activities and incentives for local stakeholders to maintain well managed and productive forest areas.

The biodiversity of the Tam Giang-Cau Hai lagoon system are or may be threaten by:

- over-exploitation of aquatic resources, such as fish, shellfish, *Gracilaria* algae and sea grass beds, and destructive fishing practices (fishing in breeding season and breeding ground, use of fine-mesh nets or electricity
- upstream catchments of the main feeding rivers (in particular Binh Dien and Dong Hoa dams on the two main tributaries of the Huong River) as well as the saline intrusion barrier of Thao Long (just upstream of the mouth of Huong River) which disrupt the hydrological regime of lagoon and the supply of nutrients to the lagoon system and hinder the migration of anadromous fishes
- pollution by the discharge of pesticides by rural area and wastewater by urban and industrial areas and oil spill from boats and ships

Recent surveys showed that the biodiversity of the lagoon is still rich with respect to the of number of taxa (see above § 4.2.3). However, local people would report a reduction in the diversity and number of both fish and bird species in the lagoon and, as regards plankton organism, their abundance (number of individuals) would be greatly altered by water pollution. In addition, important areas of seagrass appear to have declined and only two small pockets totaling 10 hectares of mangrove forests remain and even these are degraded. The IMOLA project (Integrated Management of Lagoon Activities, supported by Italy) currently under implementation aims at improving the exploitation of lagoon resources by means of sustainable technologies and methods.

4.2.7. COASTAL RESOURCES

The shoreline of the East Sea within the THH Province is 128 km long. The seawaters are rich of around 500 fish species among which 30 to 40 species are of high value such as butterfish and mackerels. According to the Statistic Yearbook, the annual catch of sea products in TTH Province amounts to nearly 20,000 tons in 2008. Fishermen from TTH Province are used to moving along the coast of Central Vietnam according to the season. Fishing lobster and other seafood is also well developed along the coast of TTH Province, especially in the vicinity of Long Co.

In the last year the fish catch from lagoon fisheries have regularly increased and now exceeds that from the sea: more than 26,000 in 2008. Likewise, the increasing production of aquaculture fish now reaches more than 4000 ton/year, which is also the production rate of the shrimp aquaculture.

4.3. INFRASTRUCTURE FACILITIES AND EQUIPMENT

4.3.1. WATER SUPPLY

4.3.1.1. Drinking water production

There are a total of 12 existing Water Treatment Plants (WTP) in the urban areas of the TTH Province (see Table 4.11).

In year 2007 the total capacity of these plants is estimated at 108,525 m^3/d. This production network should supply piped water to a service area with a population of about 415,000 i.e. 36% of a total provincial population of 1.148 million. The proportion of the population served with piped water in these urban areas is estimated at 88%. In particular for Hue city urban area, the proportion reaches 95%. Besides this some further 4% of people in these areas have access to "clean" water. The concept of "clean" water is mainly that it can be used for washing clothes and dishes, but not necessarily for drinking. The population served with piped water from HUEWACO managed systems was therefore equivalent to 368,000 in year 2007 increasing to 380,000 by year 2009 (i.e., 80,000 households or 33% of year 2009 total population of the TTH Province).

The majority of HUEWACO WTP's receive pumped water from surface water intakes on rivers. The WTP's are mainly conventional type with addition of chemicals at the inlet followed by mixing, coagulation and flocculation, then settlement followed by rapid gravity filtration and disinfection by chlorination. One WTP at Phu Bai receives water from deep wells. This water needs treatment because of high iron and salt content.

Table 4.11: Drinking Water Treatment Plants (WTP) currently operating within the TTH Province

WTP	Location	District	Year of construction (or last upgrade)	Capacity m^3/day
Quang Te 1	Quảng Tế hill, Thủy Xuân ward, Hue city	Hue City	1909	40,000
Quang Te 2			2009	82,500
Da Vien	Hue city		1953, 1996	12,000
Tu Ha	Tu Ha town	Huong Tra	1997, 2004	12,000
Binh Thanh	Binh Thanh		2000	250
Hoa Binh Chuong	Phong Hoa	Phong Dien	2004	2,000
Phu Bai	Phu Bai	Huong Thuy	2007	1,800
Chan May	Loc Tien	Phu Loc	1995	6,000
Ben Van	Loc Bon		2005	175
Vinh Hien	Vinh Hien		2003	150
Nam Dong	Khe Tre	Nam Dong	1995	2,000
A Luoi	A Luoi town	A Luoi	?	2,000

A general decision has been taken to use Poly-aluminum-chloride (PAC) as the source of coagulant. This chemical is relatively expensive compared with aluminum sulfate (also called Alum) but is more effective and readily available on the local market (or from China). In some plants, lime is added for pH adjustment. Chlorination is carried out by mixing powdered derivatives – such as sodium hypochlorite or from electrolytic salt conversion. These processes have advantages of simplicity of operation and safety in comparison with gas chlorination. However the use of powdered derivatives for chlorination is not as flexible because the output capacity cannot be varied as easily as chlorine gas.

4.3.1.2. Access to drinking water

The Table 4.12 describes the main sources of sanitary water used by the population of each district of the TTH Province in 2008 according to the Center of Clean Water and Rural Sanitation. It is showed that nearly 50% of population does not use tap water as a main source. This is particularly observed in Phu Loc, A Luoi and Phong Dien District, where sanitary water is drawn from boreholes and wells.

Table 4.12: Main source of sanitary water by population of each district of the TTH Province

District	No of households (HH)	% HH having access to sanitary water	Main source of sanitary water			
			Tap water	Borehole water	Well water	Other
Hue city	64 412	95.9%	94.7%	0.7%	0.5%	0.0%
Phong Dien district	15 785	76.4%	17.5%	27.9%	19.2%	11.8%
Quang Dien district	15 934	82.5%	48.3%	24.4%	2.0%	7.9%
Huong Tra district	18 113	80.3%	49.6%	11.2%	14.4%	5.1%
Phu Vang district	23 776	73.0%	42.0%	28.1%	2.9%	0.0%
Huong Thuy district	16 298	85.8%	54.0%	6.4%	24.3%	1.0%
Phu Loc district	21 784	74.3%	5.6%	20.4%	32.4%	15.8%
Nam Dong district	7 014	81.5%	22.4%	0.0%	20.2%	38.8%
A Luoi distict	3 555	83.9%	6.4%	0.0%	40.3%	37.3%
ALL DISTRICT	223 425	83.5%	51.7%	13.3%	11.8%	16.5%

The socio-economic survey carried out in the framework of the present PPTA observed that:

- in surveyed mountainous areas, 49% of households use dug wells (boreholes), 11% use filtered gravity water, 10% used gravity water directly abstracted from streams, 16% use gravity water from community reservoir and 36.8% use tap water supplied by HUEWACO (the over 100% total indicates that some households use different types of water sources). The distance to the drinking water source is generally comprised between 300 and 500 m with a maximum of 5 km. The water is most often transported by walking (70%) 2 or 3 times per day for 56% of households. Women are most frequently in charge of water collection and transport (71% of households).
- in plain areas, 72% of the households use wells, out of which 66% used dug wells (boreholes), and 6% use drilled wells equipped with pumping systems) and 28% use tap water provided by HUEWACO. The distance to the drinking water source is generally comprised between 70 and 300 m with a maximum of 3 km. The water is most often transported by walking (71%). Women are most frequently in charge of water collection and transport (78% of household).
- in coastal areas, 60% of households use wells (dug and drilled), 25% use piped water provided by water companies, other households using other types of water such as gravity water, community reservoir and 20 liter bottled water for eating and drinking. The distance to the drinking water source is generally comprised between 400 and 800 m with a maximum of 8 km. The water is most often transported by walking (46%) or motorcycle (30%). Women are most frequently in charge of water collection and transport (68% of household).

Although it is difficult to compare the data sources, both of them point out the deficiency of piped water supply in the rural areas.

4.3.2. SEWERAGE AND WASTEWATER TREATMENT

There is actually no formal wastewater treatment plant (WWTP) within the TTH Province. The only treatment works is the industrial water treatment facility of the Phu Bai industrial park. The totality of the domestic wastewater and the most part of industrial effluent are discharged without treatment into the sewage network or directly into the rivers and their tributaries. A project funded by Japan proposed the construction of 2 WWTP in Hue city (one works on each bank of the Huong river). The feasibility study of this project has been finalized in 2007 and the detailed study is presently underway. The construction of WWTPs is supposed to start up by 2011.

As concern small towns and rural areas, the socio-economic survey showed that 26% of survey households have no toilets. Among the household having toilets, it has been observed that:

- in urban areas, 84% of households use flush toilets equipped with adequate septic tanks and 16% use "permeable" toilets (without impervious septic tank)
- in rural areas, 57% of households use flush toilets and 42% use "permeable" toilets

People who have no toilet relieve themselves preferably in the wood nearby in both mountainous and plain areas, and in the water bodies or sand dunes in coastal areas.

4.3.3. SOLID WASTE MANAGEMENT

The solid waste production within the Hue city is nearly 300m^3/day (nearly 200 ton/day). In Hue city, the waste collection system is quite effective and comprises more than 30 waste collection sites. The collection rate of domestic solid waste amounts to more than 90%. The solid waste collected with Hue district are conveyed into the Thuy Phuong landfill (Thuy Phuong Commune, Huong Thuy District). The landfill has a capacity of 800,000 m^3 (20 ha); it has been extended in 2008 for a next 8 year operation phase. A solid waste treatment plant was constructed in 2006 in the vicinity of the landfill. This plant recycles waste into compost and plastic products with a capacity of 200 ton/day.

New landfills have been recently constructed (A Luoi, Phong Dien) or planned in each district for receiving all the solid waste produced in the districts of the THH Province by 2010.

The hospital solid waste production is about 300 kg/day. The Hue central hospital burns its waste in its own incinerator, constructed in 1999, with a capacity of 200 kg/day. Other hospitals treated their waste by burning and/or burying. Industrial solid waste are mostly treated within the producing facilities. It is recalled that there are no heavy polluting industries, in terms of solid waste, within the TTH Province. A new public incinerator with a capacity of 200 kg/day for the treatment of both industrial and hospital waste of the TTH Province is under study.

4.3.4. TRANSPORTATION NETWORK

The road network of the TTH Province is more than 4200 km long including 439 km highway, 525 km district road and 256 km commune road. More than 95% of the commune centres can be reached by roads suitable for motor vehicles. However, the paved road network in rural areas (and especially in mountainous areas) still has a low density.

The waterway network comprised rivers and lagoons and is 563 km long. The TTH Province has two main ports located on the inner bank of the lagoon: Thuan An port and Chan May port. Thuan An port is located 13km downstream of Hue city, with 5 piers and a 150m length, it can harbor 2000 tons ships. Chan May deep water harbor is nearly 50 km away from Hue city (to the south-east, with a 360m length, it can harbor 30,000 tons freight ships and 3500-person tourist ships.

The TTH Province is crossed by North-South railway line (101 km within the Province) and counts 3 train stations: Hue (Bui Thi Xuan street, closed to city centre), Van Xa, and Phu Bai. These stations total more than 100,000 tourists per year.

The Phu Bai airport is located 15 km to the south of Hue city. The runway is 2700 m long and has a current annual traffic of nearly 260,000 passengers.

4.3.5. POWER SOURCES AND TRANSMISSION

According to the national plan, 11 hydropower plants will be operating by 2015. The main operating power plant is Binh Dien (capacity 44 MW) and other medium-large capacity hydropower plants are under construction such as Huong Dien (54 MW) and A Luoi (170MW) or under feasibility such as A Lin (62MW). Other small capacity (3 to 10 MW) plants are under feasibility or design study. Presently the TTH Province takes its power mainly from the interconnected national network, which includes: 110 KV Da Nang – Hue network, Dong Hoi – Hue line and 220KV network Hoa Khanh – Hue. To prevent power shortage, there is a small scale diesel power station with a capacity of 8 MW in Ngu Binh, within Hue District.

The TTH Province is a part of the key economic zone of Central Vietnam and albeit less economically developed than the neighboring Da Nang Province, is considered to be a province of breakthrough in socioeconomic development speed. Average annual growth of Gross Domestic Product (GDP) has achieved nearly 10% between 2001 and 2005. In 2006 the economic growth was nearly 12% and the average income/person achieves 9.28 million VND according to the Province statistics.

The main objectives set up by the planning authorities for the TTH Province up to 2015 are as follows:

- Industrial sector: develop industrial processing products with modem technological qualifications and competition capacity such as aquaculture production, mine ores, construction materials production, garment and textile industry, mechanical repair and process, hydroelectricity and software technology
- Transport and telecommunication sector: develop airline, shipping, international telecommunication, finance, banking, insurance, information technology, health and education with high quality
- Agricultural sector: develop application of science and modern technology to agricultural, forestry and aquaculture activities with the view of producing high quality products.

The objectives of economical growth in TTH Province by 2020 are: over 10% of annual GBP growth, 400 USD/person/year of average exportation value (currently 40 USD), urbanization rate of 55% (currently 45%). In terms of social development, the target indicators to be reached by 2010 are: less than 20% of malnourished children under five, more than 95% of children under five going to the kindergarten, more than 70% of primary schools compliant with national standards and more than 95% of households are supplied with fresh water.

In the framework of this feasibility study, a socio-economic survey has been carried out in 2009 among 20 communes located in suburban and rural zones of the TTH Province: 10 communes in the mountainous area, 3 communes in the plain area and 7 communes in the coastal area. In these surveyed communes, 1102 households received a questionnaire and 38 in-depth interviews were carried out. For the surveyed population, the average monthly income was 3.115 million VND (i.e.: US$173)/household and the average yearly expense was 2.219 million VND (i.e.: US$123) /household. According to the topographic areas, the breakdown of income is: 3.625 VND (US$201)/month for suburban towns, nearly 3.250 VND (US$180)/month in the plain and coastal areas and nearly 2.900 VND (US$161)/month in mountainous areas. According to Decision No 170/2005/QD-TTg of the Prime Ministry on 08 July 2005, the poverty limits in Vietnam are the following: 200,000 VND/per capita per month in rural areas and 260,000 VND per

capita per month urban areas. These values are presently under actualization and should be significantly raised (up to 350,000 VND for rural and 400,000 VND for urban areas).

4.3.6. LAND USE

In the TTH Province the land use is closely linked to the topography (see Fig. 10). The uplands are mainly covered by forest, a part of which are strictly protected. Local population cultivates the most gentle hillsides and valley bottoms with vegetables or rice. Some land is also occupied by planted forests. Planted forests are also well developed on the transition, hilly land between uplands and lowlands.

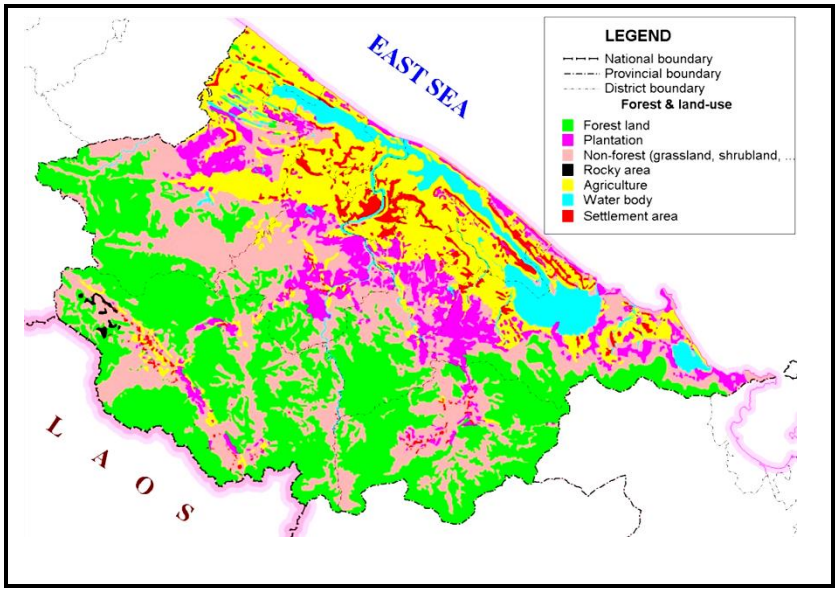


Figure 10: Land use map of the TTH Province

Cropland occupies the most part of the plain and coastal area, shared between irrigated rice fields, mostly located in the vicinity of river and water bodies, and rainfed plots. Lagoons are used for fishing and aquaculture. Some plantations have been set up on the sand dunes with a view of stabilization and fighting against erosion.

The landscape and land use prevailing in the surroundings of the WTPs to be constructed by the Project are featured and illustrated Table 4.13.

Table 4.13: Pictures of rivers used for water production

Future new WTP	Landscape and land use in the surrounding area	Representative picture
Phong Tu	Gently undulated land. Rural area, vast planted forest of pine and cajeput trees (forest), bamboo tree along the river. No paved roads.	
Quang Te	Small hill within Hue City. Urban, structured area. High and medium standing households. Urban vegetation	
Loc Bon	Gently undulated land. Rural area, plantation of cajeput trees but no agricultural crops nor settlements. Many tombs.	
Loc An	Buffer zone of Bach Ma National Park. Gently undulated land. Rural area with some small-scale agricultural plots and planted trees. Dispersed rural settlements.	
Loc Tri	Buffer zone of Bach Ma National Park at the limit of the core protected zone. Hilly/mountainous zone, mainly covered by secondary forest, no settlements	

4.3.7. AGRICULTURAL DEVELOPMENT AND FORESTRY

There are nearly 71,000 ha of cropland in the TTH Province (2008 Statistical Yearbook) sharing into 52,000 ha of annual food crops, 3800 ha of fruit crop, 4800 ha of annual industrial crops and 9800 ha of perennial industrial crops.

Riceland covers 50,800 ha (98% of total annual cropland) and other cereals only nearly 1600 ha. Rice production amounts to 280,100 tons of paddy with a mean yield of 5.5 ton/ha. Other cereals are mainly maize (1,500 ha in 2008) with a mean yield of 34 ton/ha. The main other food crops, which can be planted on rice fields after harvest and drainage of the plots are sweet potatoes (4300 ha, 4.6 ton/ha) and cassava (7200 ha, 18 ton/ha).

Peanut (4100 ha, 1.5 ton/ha) is the main annual industrial crop, followed by coffee (915 ha planted), sugar cane, sesame and tobacco surfaces are modest. Rubber tree is planted on 8380 ha.

Fruit crops are mainly citrus fruits (920 ha, 9,600 ton), pineapples (630 ha, 4600 ton) and bananas (530 ha, 10,100 ton).

As regards the livestock, the TTH Province counts around 31,000 buffaloes (used for rice cultivation), 27,000 cattle, 222,000 pigs, 6300 goats and 1.6 million poultry.

Planted forests cover 4759 ha. During the year 2008, 171,400 m^3 of wood and 5,600 m^3 of firewood have been extracted, as well as 5.5 million of bamboo stems and 480 ton of pine resin.

4.3.8. FISHING AND AQUACULTURE

Fishing and aquaculture sector employs more than 7% of the working population. In 2008, the total fish catch has amounted to 26,626 tons (against 20,347 tons in 2004) among which the sea production was of 19,825 tons (against 15,098 tons in 2004).

The aquaculture sector is also well developed in the Province, especially in the lagoons: 4,056 tons of shrimps and 4311 tons of fishes where produced by aquaculture farms in 2008, against respectively 3443 tons and 1905 tons in 2004.

The vast majority of fishing and aquaculture activities are carried out in the lagoon areas. Fishing activities are carried out in 31 communes and towns around the lagoons by about 3450 households using nearly 6000 units of fishing gears and more than 4000 boats, among which 1900 without engine. The most popular fishing gears are: fish corral (1378 units), trammel net (1371 units), bottom net (1012 units), small scale drift gill net (724), crab gill net (551).

Fresh water aquaculture is performed by nearly 1000 households in 20 communes around the lagoon. A 150 ha surface is dedicated to this activity. The two most frequent cultured species are Common carp (*Cyprinus carpio*) and Grass carp (*Ctenopharyngodon idellus*).

Brackish water aquaculture is performed by about 5740 households in 31 communes and towns around the lagoon. More than 6000 ha are dedicated to brackish water aquaculture activities, which include pond culture, net enclosures and cage culture. There are about 3100 ha of high tide pond, 2150 ha of low tide pond. Moreover, 780 ha of net closure and nearly 500 cages are being employed for the brackish aquaculture.

Most of the ponds are used for shrimp culture (about 2750 ha, accounting for 89% total areas of brackish water pond). The poly-culture is very common for the net closure aquaculture. About 85 % of the total cages are used for fish production, the rest being used for production of molluscs.

Because starting with a poor technical assistance, the development of fisheries and aquaculture has rapidly caused marked degradation to the aquatic ecosystem and hence

increased vulnerability of the lagoon people. In order to invert the trend and improve the environmental management of the increasing activities, FAO have launched in 2005 the IMOLA Program (Integrated Management of Lagoon Activities in Tam Giang Cau Hai Lagoon) funded by several donors which is starting its second phase (2008 - 2010). This 2.7 million dollar Program has many components such as: biological and physicochemical characterization, legal and regulation aspects, support to provincial/local institutions relating to the aquaculture sector for capacity building, socio-economic assessment and technical, organizational support to fishermen groups.

4.3.9. MINERAL RESOURCES

The TTH Province has many mineral resources among which:

- metal ores: titanium (5 million ton reserve, exploited from coastal sand since 1992), iron (3 million ton reserve) and gold (1000-1500 kg reserve)
- raw construction material: limestone (exploited for cement in 6 mines, nearly 1 billion m^3 reserve), kaolin and other clays (more than 25 million tons reserve), sand (exploited from the banks of Huong River and its tributaries), granite (nearly 30 million m^3 reserve)
- fuel minerals : peat, only used for preparation of organic fertilizer so far (1.6 million ton reserve)

Moreover, the Province exploits mineral water and hot natural water sources (7 hot springs).

4.3.10. INDUSTRIES AND HANDCRAFT

Albeit not being traditionally an industrial region, the TTH Province has experienced a rather high industrial growth for the last past decade, but still far from that met in other Vietnamese provinces. The main industrial products manufactured in TTH Province are beer (Huda Beer® and Festival Beer®, 47 million L/year in 2008) and cement (546 million tons/year). Most of the industrial activities are located within or in the vicinity of Hue city.

4.3.11. TOURISM FACILITIES

Thua Thien Hue Province has a plethora of attractions for domestic and international visitors. Hue was the capital city of Vietnam during the Tay Son and Nguyen dynasties; in recognition of its cultural value the partially-restored citadel in the heart of Hue has been declared a UNESCO World Heritage Site. Other major cultural and historical tourist sites are the ancient tombs located upriver from Hue on the Huong (Perfume) River.

Beside the "built" cultural heritage, the TTH province also boasts considerable natural attractions, including both coastal (Hai Van Pass, Thuan An estuary, Lang Co Beach, Canh Duong and Cau Hai-Tam Giang Lagoon) and mountainous (Ngu Mountain, Bach Ma Mountain) sceneries that may be valorised by classical (leisure) and ecological tourism.

In 2008, there were 148 hotels and 131 tourist houses in TTH Province, most of them located in Hue City. The Province has accommodated 815,786 national visitors and 709,473 foreign visitors during the same year (TTH Province Statistical Yearbook). Less than ten years before, in 2000, the tourists were not more than nearly 275,000 national and 195,000 foreign visitors.

4.4. SOCIAL AND CULTURAL RESOURCES

4.4.1. POPULATION AND COMMUNITIES

According to the official statistics, the population of the TTH Province reached nearly 1.5 million people in 2008, 30% of whom were living in Hue City, which covers only 1.5% of the territory (see Table 4.14). The remaining population mostly dwells on coastal and plain areas (see Fig. 11). The mountainous areas only accommodate less than 6% of the population on more than 37% of the territory. The sex ratio is 0.97 and 65% of the population lives in urban area. In 2007, the measured birth rate was 16.6‰ and the death rate was 4‰ resulting in a natural growth rate of 12.6‰. This rate was over 20‰ ten years before (1997).

Table 4.14: Demographic data of the TTH Province

Natural Areas	District	Surface area (km^2)	Population 2008	% population	Density (inh./km^2)
Hue	Hue city	71	339 822	29.6%	4787
Plain	Huong Thuy	458	97 278	8.5%	212
Plain	Huong Tra	522	117 654	10.2%	225
Plain + coast	Phong Dien	954	107 122	9.3%	112
Coast	Quang Dien	163	91 799	8.0%	562
Coast	Phú Vang	280	176 896	15.4%	632
Mountain + coast	Phú Loc	730	151 636	13.2%	208
Mountain	A Luoi	1233	42 392	3.7%	34
Mountain	Nam Dong	652	23 725	2.1%	36
Total TTH Province		**5063**	**1 148 324**	**100.0%**	**227**

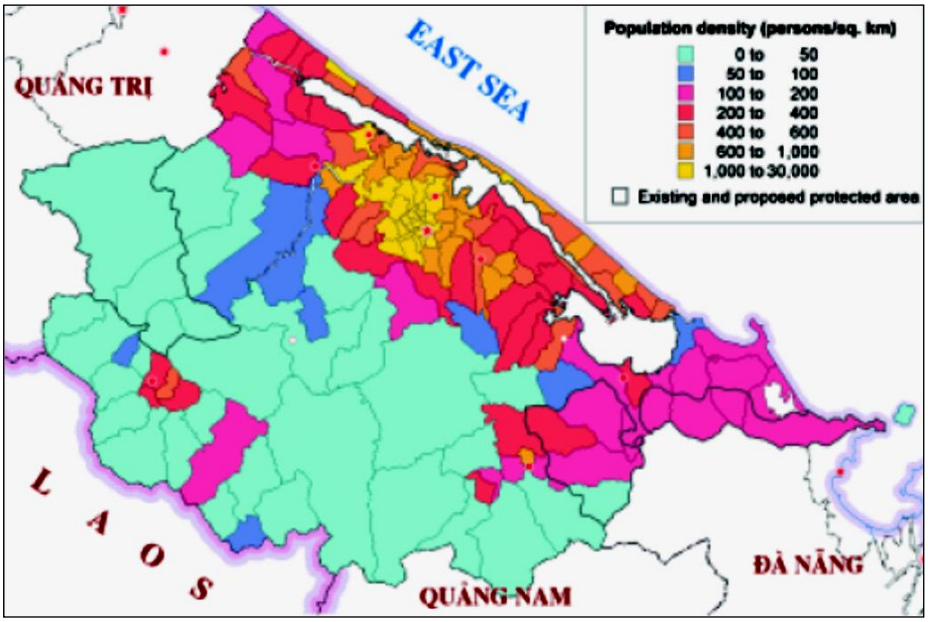


Figure 11: Illustrative picture of the repartition of the population over the TTH Province (based on 2002 data)

The Kinh People constitutes the vast majority of population (96.17% in 2009). The ethnic minorities, who thus constitute less than 4% of the population, are mainly comprised of the following peoples: Pa Ko (1.56 % of total population of TTH Province), Co Tu (1.24%), Ta Oi (0.98%), Pa Hy (0.016%), Van Kieu (0.013%). The ethnic minorities mostly inhabit the mountainous areas (A Luoi and Nam Dong Districts). According to the census, the Co tu People is the only ethnic minority dwelling in the Nam Dong District.

4.4.2. HEALTH FACILITIES AND HEALTH ISSUES

The Vietnamese health care system includes both private and public facilities. According to the 2008 Statistical Yearbook, the TTH Province counts 35 hospitals and clinics (15 in Hue city, 1 or 2 in the other Districts), 2 maternity houses (both in Hue city) and 150 medical service units (25 in Hue city). All these facilities accommodate 4099 beds, 70% of which (3888) are located within Hue city. The number of doctors (who can practice surgery) and physicians (who can only prescribe medicine) are respectively 1467 (1136 in Hue) and 1100 (678 in Hue). Thus the doctor rate is of around 10/10,000 inhabitants, which tenfold the WHO standard (1doctor/10,000 inhabitant).

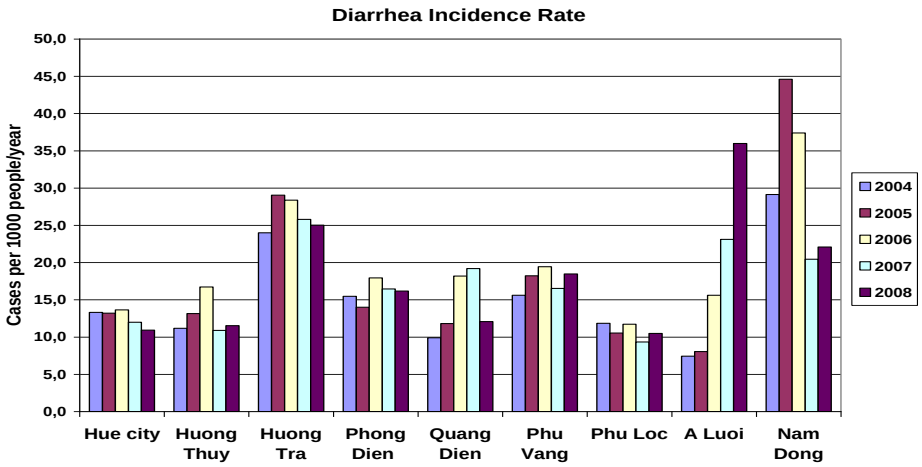
Epidemic control and preventive health services for the entire TTH Province including delivery of vaccines are provided by the Provincial Prevention Medical Centre (PMC). The proportion of children under-one-year who are fully vaccinated reaches more than 98% (stable since several year). The proportion under-five-year children subject to malnutrition is 20%, against 28.5% five years before (in 2004).

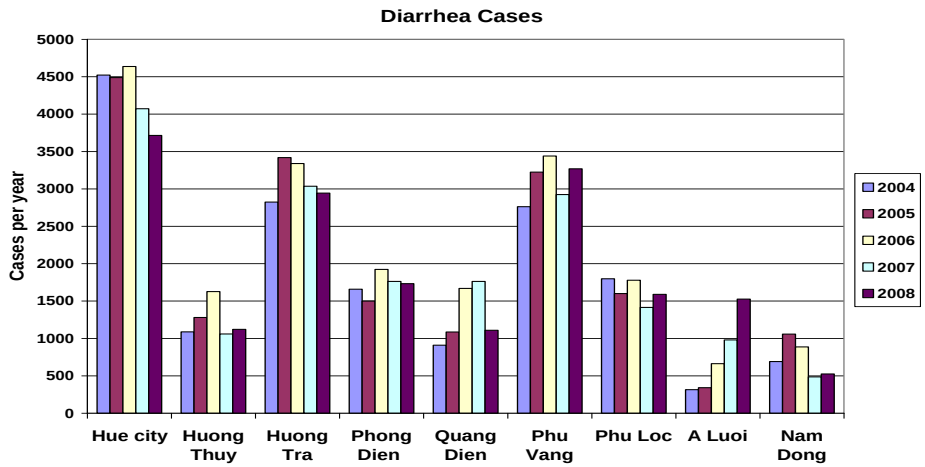
As regards the waterborne diseases, the epidemiology services monitor as a routine the following pathologies based on data collected at health centres: diarrhea events, amoebic dysentery cases, bacterial dysentery cases, dysentery syndromes (symptoms resembling those of dysentery but without confirmation of presence of the pathogen agents), typhoid fever cases and cholera cases. The Figure 12 indicates both the cases and the incidence rates of some indicators in each district for the past 5 years.

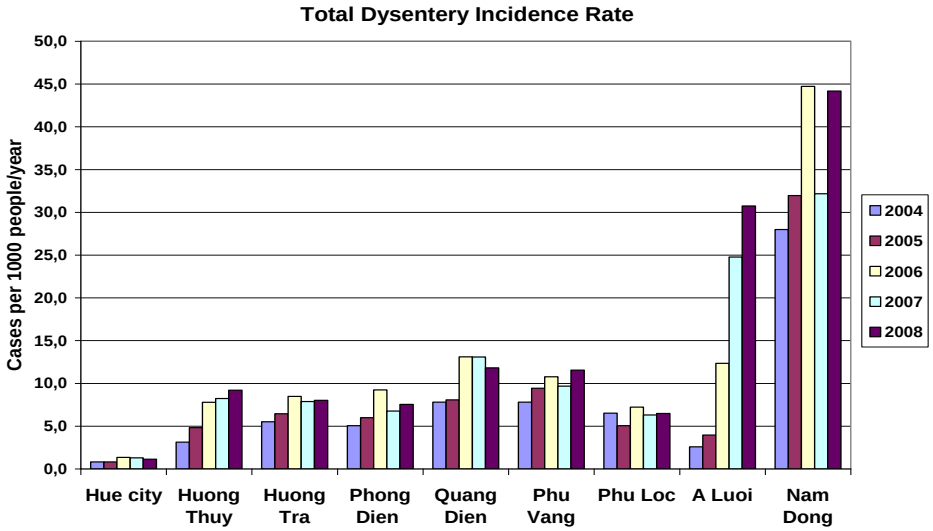
There was a major cholera outbreak in TTH Province during the years 1992 and 1993 with more than 1000 cases each year. Since then, only few cases appeared some times, the last ones in 2003, with less than 100 cases in the all Province. Before 2000, Hue was known as a "black spot" for typhoid fever with an incidence (216 cases/100,000 inh. in 1995-1999) nearly twofold higher than in the rest of Vietnam. Since then, typhoid cases have fortunately dropped: 16 cases in 2004, 25 cases in 2005 and in 2006, 7 cases in 2007 and no case in 2008.

Figure 12 demonstrates that the mountainous A Luoi and Nam Dong districts show the highest incidences of diarrhea and dysentery, but given the low population densities, the resulting numbers of cases stay at lower or comparable level as the other district. Hue district shows markedly the lowest incidence of dysentery in a such way that it remains the least affected in terms of cases despite it counts for 30% of the total province population. Among the other non mountainous districts, the Phu Vang District located in coastal zone and on both sides of the lagoon (right bank of the Huong River), shows clearly the most numerous cases of dysentery (about 2000 cases in 2008, against 400 cases in Hue District). Two things should be considered in associating these epidemiological data with water quality: on the one hand, the cases reported by public health services generally underestimate the real number of cases, especially when the affected people are poor and/or live in rural/remote areas and, on the other hand, diarrhea and dysentery cases are not only dependant upon water quality but also upon food quality and hygiene practices. Anyway is one excludes the two extreme that are Hue City and the mountainous districts, there is no reason for the remaining district to have less access to the health services and to show differences in terms of hygiene practices, so the higher number of dysentery cases in the Phu Vang may be explained by the fact that this district shows the lowest rate of household having access to sanitary water (see above Table 4.12 in § 4.3.1.2).

Malaria, not a waterborne but a water-related disease, is only observed in mountainous areas (A Luoi and Nam Dong Districts).







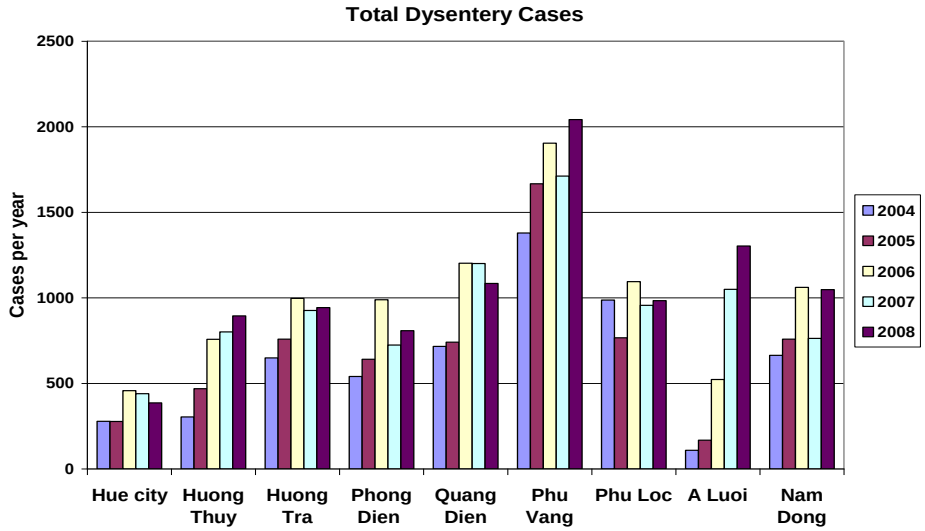


Figure 12: Incidence and cases of diarrhea and total dysentery (amoebic + bacterial + dysentery syndromes) for each districts of TTH Province

The Department of Public Health (DOPH) of the TTH Province, through the Division of Preventive Medicine, carried out monitoring of drinking water in both HUEWACO network and other water supply system, bur the sampling is very limited (30 samples once a month for urban area and twice a year in mountainous areas) as well as the parameters (total coliforms, faecal coliforms, *Vibrio cholerae*, residual chlorine and few other chemical parameters). As a Provincial authority, the DOPH can urge HUEWACO to raise the chlorine concentration of supplied water, especially if epidemic outbreak is suspected. But generally speaking, the health authority relies on HUEWACO, which is better equipped for water analysis, to ensure a good quality water production and to monitor it on a reliable way, and it rather focuses on sanitation issues that are another significant cause of infectious diseases and epidemics.

4.4.3. EDUCATION FACILITIES

According the Statistical Yearbook, in 2008, the TTH Province had 200 kindergartens which accommodate 38574 pupils, 236 primary schools (104,460 schoolchildren), 144 secondary schools (134,724 schoolchildren). In addition, there are several professional schools, colleges and institutes and universities. As primary schools are well spread over the Province's territory as compared with the population, the upper secondary schools are relatively more numerous in Hue District. The teacher/pupil rate for primary school is varies between 20 and 25 for Hue, Huong Tra, Huong Try, Phu Vang, Phu Loc, is around 16 in Phong Dien and Quang Dien Districts, and around 13 for the Nam Dong District.

4.4.4. SOCIO-ECONOMIC CONDITIONS

According to the Statistical Yearbook, in 2008, the main employing sectors in the TTH Province are: agriculture and forestry (31.8% of employments), manufacturing (17.6%), trade of goods (12.1%), construction (8.2%), fishing (7.2%), transport (5.5%), hotel and restaurant (5.3%) and education (3.4%). The official unemployment rate has slightly decreased from 2001 (6%) to 2008 (5.5%) and is weakly lower for women (5.3 % against 5.7% for men in 2008).

The socioeconomic survey carried out in the present Technical Assistance has revealed that, in the project area out of Hue city, the average monthly household income was VND3.115.482 (US$173) and the average monthly household expenses VND2.218.599 (US$123). Actually the income varies with the zones of TTH Province and, more essentially, with the activities developed in these zones. For in Phu Bai (Huong Thuy District) and Phong Dien towns, relying mainly on agriculture and forest exploitation, the average income is around VND2.7 million whereas the income reaches more than VND3.2 million in Lang Co town (Phu Loc District) where the prevailing activities are service, trade and tourism, and more than VDN 4.5 million (US$250) in Thuan An town (Phu Vang District) where fish farming is well developed. In rural areas, the ethnic minorities are most often poorer that Kinh people, the ratio between both average incomes may vary between 2 and 6.

4.4.5. PHYSICAL OR CULTURAL HERITAGE

Hue was the capital city of Vietnam during the Tay Son and Nguyen dynasties, as a result, the cultural heritage in TTH Province is rich and diversified, including both tangible and intangible settings; in recognition of its cultural value the partially-restored citadel in the heart of Hue has been declared a UNESCO World Heritage Site. Other cultural and historical attractions are the ancient tombs located upriver from Hue on the Huong (Perfume) River which have been also listed by UNESCO as the World Cultural Heritage.

In addition to the “listed” buildings and sites, many pagodas from different periods are scattered all over the TTH Province. Beside old pagodas dating more than a century ago one can find series of new pagodas built in the last past decade under private funding,

most often coming from Vietnamese Diaspora members. These new pagodas are particularly numerous in Hai Duong Commune on the sand barrier. In many places, the cemeteries show a very large extension which may hinder the construction of infrastructure such as water mains. However, cemeteries are considered private and, if the need arises, their displacement is to be managed through resettlement plans.

Some old public buildings/sites, especially those constructed during the French presence can also be considered as part of the cultural heritage. A typically relevant example is the first Pumping Station set up in 1909 on the Huong River and still operated by HUEWACO which has been very well restored for the centenary of the water company.

5. SCREENING OF POTENTIAL ENVIRONMENTAL IMPACTS AND PROPOSED MITIGATION MEASURES

5.1. ENVIRONMENTAL SCOPING AND SCREENING

5.1.1. SOURCES OF IMPACTS AND APPROACH TO ENVIRONMENTAL ASSESSMENT

As mentioned above, the Project will consist of setting up and/or upgrading drinking water production and distribution in 8 independent water supply zones (WSZ) within the territory of the TTH Province. In each WSZ, the planned works will be at minimum construction or extension of a drinking Water Treatment Plan (WTP) and laying water pipe in order to transport or distribute drinking water. Basically, the impacts generated by a project are spread over three phases:

- pre-construction phase: detail design studies, bidding documents (including environmental requirements), selection of contractors and surveyors, procurements. No concrete impacts occur during this phase but its outputs may significantly influence the occurrence and/or magnitude of impacts during the next phases
- construction phase: works related to the construction/extension of WTP (including land clearing and scouring) and ancillary equipment (intake station, etc.), construction of booster stations and their water tanks as well as laying of water pipes (including notably trench digging and filling)
- operation phase: activities associated with water intake, water treatment, storage, transport and distribution of raw and drinking water.

Since infrastructures are supposed to operate during several decades and no hazardous substances are involved in the processes, environmental assessment for dismantling activities are generally not addressed in water supply projects.

Physically the Project consists of a set of 11 independent subprojects with respect to the construction (see above § 3.2).

Based on field visits, initial consultation of stakeholders and reviewing of the relevant documentation, a preliminary environmental scoping of the Project has been performed with a view of pointing out potentially serious, important and moderate impacts that would need to be mitigated. These preliminary statements helped to identify the relevant sources of impacts which have been thereafter confronted with the environmental components of the Project in order to bring out the potential impacts which require a further assessment. The results of this environmental scoping are set out in Table 5.1 and 5.2.

In line with standard environmental impact assessment (EIA) practice and the Asian Development Bank guidelines, the impacts identification covers the direct effects and any indirect, secondary cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the sea outfall during its construction and operation.

Table 5.1: Results of environmental scoping of the TTH Province Water Supply Project during construction phase

Component	Potential direct adverse impacts	Impact Sources	Generating Activities	Indirect potential impacts induced
Air	Rise of noise and vibration level	Engines	Movement and work of heavy machinery	Disturbance of fauna
	Air pollutant emissions	Emission of exhaust gases	Movement and work of heavy machinery	Adverse effects on public health and welfare
		Emission of dust	Movement and work of heavy machinery, transport of spoil material	Adverse effects on public health and welfare
Soil	Loss of natural soil	Soil excavation	Trench digging, earthworks on WTP sites	Destruction of flora and fauna
	Pollution of soil	Spillage of lubricant, fuel and solid waste	Movement and work of heavy machinery, fueling operation	Pollution on surface and ground waters
Fresh water	Pollution of surface and ground waters	Spillage of lubricant and fuel , discharge of spoil material	Movement and work of heavy machinery, fueling operation *Particularly of concern during construction of water intake stations*	Pollution of lagoon and sea water Decrease of freshwater and marine resources and biodiversity
Terrestrial flora and fauna	Destruction of terrestrial vegetation	Scouring, soil excavation	Site reparation, trench digging *Particularly of concern during laying of water pipes*	Increase of soil erosion Loss of biodiversity
	Destruction and disturbance of terrestrial fauna	Soil excavation	Site preparation, trench digging and backfilling *Particularly of concern during laying of water pipes*	Loss of biodiversity
Human and socio-economic environment	Unforeseen damage to private goods and public goods (*)	Soil excavation	Trench digging *Particularly of concern during laying of water pipes*	Adverse effect on population standard of living
	Disruption to road traffic	Encroachment on the carriage ways	Trench digging *Particularly of concern during laying of water pipes*	Loss of time and its consequence on local economy
	Disruption to public services	Cutting power and water, damage to the networks	Movement and work of heavy machinery, trench digging and backfilling *Particularly of concern during laying of water pipes*	Adverse effect on population standard of living
	Increased accidental risk for local population	Encroachment on the carriage ways, excavations, disposal of spoil material,	Movement and work of heavy machinery and contractors vehicles, trench digging *Particularly of concern during laying of water pipes*	Accidents and injuries
	Nuisances to health and welfare of the nearby population	Emission of noise, vibration, dust and air pollutants	Movement and work of heavy machinery, fueling operation, trench digging and backfilling	Adverse effects on public health and welfare

(*) Planned destruction of private goods is managed through the resettlement process

Table 5.2: Results of environmental scoping of the TTH Province Water Supply Project during operation phase

Component	Potential direct adverse impacts	Impact Sources	Generating Activities	Indirect potential impacts induced
Air	Rise of noise and vibration level	Pumps	Raw and drinking water transport and distribution (intake station, booster station) Drinking water production (WTP)	Disturbance of fauna Nuisance to population welfare
Soil	Increase of soil erosion	Bare soil on steeply sloped land	Clearance of pipe routes above ground	Loss of soil, aesthetic nuisance
Fresh water	Pollution of surface waters	Discharge of treatment sludge (aluminum compounds)	Drinking water production (WTP)	Pollution of lagoon water Toxicity to aquatic fauna and flora Decrease of freshwater and marine resources and biodiversity
	Decrease of freshwater level	Raw water abstraction by intake station	Drinking water production (WTP)	Damage/change to aquatic fauna and flora Risk of riverbed drying Decrease of water resources for agriculture and fisheries
Aesthetic of scenery	Unsightly building damaging beautiful scenery	Buildings sheltering pumping station, premises of WTP, water tanks and treatment works	Raw and drinking water transport and distribution (intake station, booster station) Drinking water production (WTP)	Damage to aesthetic of tourist places
Human and socio-economic environment	Nuisances to welfare of the nearby population	Emission of noise and vibration	Raw and drinking water transport and distribution (intake station, booster station) Drinking water production (WTP)	Adverse effects on public health and welfare

5.1.2. UP-DATING ENVIRONMENTAL SCREENING

The Project has been screened and classified as an Environmental Category B project which requires an Initial Environmental evaluation (IEE). However, the first screening has been carried out without detailed knowledge of the design of the Project, in particular with respect to the locations of the new WTPs and water intakes to be constructed. Accordingly, it has been deemed important to review the check-list for Rapid Environmental Assessment (REA, ADB 2003) of Water Supply projects in the light of the new project design data. Table 5.3 describes the aspects likely to trigger a "Yes" answer to the REA screening questions.

Table 5.3: Aspects likely to trigger a "Yes" answer to the REA screening questions of Rapid Environmental Assessment for water supply projects (ADB, 2003).

Screening Questions (REA, ADB, 2003)	Subprojects of concern	Remarks
Project siting		
Densely populated area	Quang Te	Resettlement limited to the site of new WTP
Protected area	Loc Tri	Only water intake and raw water pipe located within the core protection zone of Bach Ma National Park but within zone dedicated to administrative/tourist activities
Buffer zone of protected area	Loc An Loc Tri	BZ of Bach Ma National Park
Special area for protection of biodiversity	Nam Dong A Luoi	Within the WWF "Green Corridor" but in small tows
Potential environmental impacts		
Inadequate disposal of sludge	All	Drying beds under construction in Quang Te. Other WTP discharge sludge into watercourses
Dislocation or involuntary resettlement of people	Quang Te	Resettlement Action Plan in preparation
Continuing soil erosion from construction operations	All	Possible in scoured strip above the buried pipes in rural areas
Excessive abstraction of water affecting downstream water users	Loc Tri Loc An Loc Bon	Possible because the river flow in dry season is unknown (needs further assessment)
Increase sewage flow due to increase water supply	All	No wastewater treatment plant operates currently within the TTH Province

Although Table 5.3 reveals concerning questions relating to the location of subprojects and the potential impacts, all the impact potentially caused by the Project are deemed moderate or mitigable.

5.2. POSITIVE IMPACTS

5.2.1. DURING CONSTRUCTION PHASE

5.2.1.1. Direct employment of local staff

The construction phase will create job opportunities for both unskilled and skill manpower mainly recruited within TTH Province. The main staff-demanding activities will be civil works and construction of WTP and laying water pipes. Over the 2010-2020 period, it can be assumed than the implementation of the total project will more than 10,000 man-months of workers.

5.2.1.2. Induced commercial activities

In addition to jobs, the activities relating to construction of works and laying pipes will increase the need for small equipment, material and services which will increase the economic activity of TTH Province, including the services to the workers (restaurant and so on).

5.2.2. DURING OPERATION PHASE

5.2.2.1. Improvement of public health

According to the epidemiological data (see § 4.4.2), the populations of rural areas of the TTH Province pay an heavy toll to the lack/shortage of potable water compliant with relevant health standards. Although cholera and typhoid outbreaks seem nowadays under control within the TTH Province, diarrhoea and dysentery incidence rates are particularly high in both mountainous and lagoon areas, where the water supply networks are less developed. Even if these diseases are not exclusively linked to drinking water (but also to food), a significant decrease of waterborne infections can be expected to the medium term after the completion of the Project in the areas currently at risk. Health of children should be the main beneficiary of the improvement of drinking water supply.

All the water resources used for drinking water production are compliant in quality with the Vietnamese standards except for phosphorus with is not of health concern (see 4.1.6.5). Actually toxic trace elements such as heavy metals and cyanide are not measured frequently (every 6 month for treated water) but no major pollution sources likely to release such toxic substances into rivers have been identified upstream the intakes. Polyaluminum Chloride (PAC) which is used as a coagulant is very effective for ensuring a good quality of drinking water, in particular, it shows better performance than classical coagulant (alum of Iron chloride, for example) for the removal of organic matter and toxic metalloids such as arsenic and antimony. Advanced removal of organic matter from raw water is quite critical because the disinfection is made with chlorine which may form toxic substances (such as trihalomethans) with organic compounds.

5.2.2.2. Time saving and economic growth

Time spent to collect potable water, particularly in rural areas, is often long as compared with that available for other basic activities (housekeeping, agricultural work, purchasing goods and so on). Moreover, for children, women and elderly, water collection can require difficult efforts. For many people, development of drinking water production and supply network will result in both time and effort saving, which will improve their welfare or/and increase their economic productivity. Add to the expected improvement of health, economic growth of the TTH Province will very likely be enhanced by the Project.

5.2.3. ENVIRONMENTAL ENHANCEMENT MEASURES (FOR THE RECORD)

In order to enhance the beneficial effects of the Project and more specifically to extend them to the all categories of the TTH Province population including most vulnerable groups, it has been planned to implement, in parallel to the main "infrastructure" project, two accompanying project addressing:

- the rural population living in areas non served by the pipe networks supplied with treated water by WTP
- the "boat people" living traditionally on boats floating the main rivers who have no direct access to piped water.

These people are known for suffering from waterborne diseases to a markedly greater extent than the other population.

5.3. POTENTIAL NEGATIVE IMPACTS

5.3.1. DURING CONSTRUCTION PHASE

5.3.1.1. Impact on noise and vibration

Rise of noise and vibration levels

The works, especially those relating to digging, laying pipes and trench filling will require machines such as bulldozers, tractors, graders and trucks that will produce high levels of noise. Noise level emitted by this machinery can reach 90 dBA each at 15 meters distance.

It is clear that the noise level of the worksite will rise significantly for the duration of works but the rise of noise level will be mostly perceived in rural/natural areas. Actually in densely populated areas the existing level is already high (see § 4.1.9) due to the vehicles traffic and the usual urban activities. Since noise levels do not add arithmetically but geometrically, the noise ground level will attenuate the nuisance of noise caused by the Project except in the close vicinity of works. In conclusion, it can be assumed the main impacts associated with noise and vibrations can be limited to the populations located less than 100m away from the worksite in urban areas and less than 500m in the urban areas. In this case, the impacts may only be significant for the sensitive population such as schoolchildren or hospital inpatients. Animals, especially birds, may also be disturbed by noise during critical periods such as nesting and breeding, but the related impact may only be significant in areas of ecological interest such as primary forest or wetlands.

Mitigation measures

Vietnamese regulation comprises national standard for noise and vibration levels in residential area (TCVN 5949:1998 and TCVN 6962:2001). However, continuous monitoring of noise and vibration level would be technically difficult, especially on "moving work sites". Moreover, exceeding standard values is sometimes not avoidable for certain works, especially in urban zones where the basic noise level is already high, and monitoring cannot be considered as an actual prevention measure.

Generally speaking, the contractor shall consider noise and vibrations as an environmental constraint in his planning and execution of the works and try as much as possible to attenuate this constraint by:

- using equipment conforming to national international standards and directives on noise and vibration emissions

- maintaining exhaust systems in good working order, properly designing engine enclosures, using intake silencers where appropriate and regularly maintain noise-generating equipment
- restricting working noisy activities between 07 a.m. to 17 p.m. within the residential areas
- informing management staff of likely impacted schools and hospitals about the work program in order to find arrangements for limiting the nuisance

5.3.1.2. Impacts on air quality

Emission of dust and exhaust gases

Two main sources of air pollution will occur during the construction works:

- earthworks (site scouring, trench digging and filling and transport of material) may generate large quantities of dust during the (long) dry season. These particles are not really toxic per se, but they may cause discomfort to the affected population and sometimes health effects such as conjunctivitis and cough. In the rural/natural areas, dust deposit on the plant leaves may affect photosynthesis.
- movements/operation of vehicles (including ships) and heavy machinery involved in the works, that will cause emission of toxic exhaust gases and fine particles

It has been shown that air pollution is not a real concern in the TTH Province except in the areas of heavy car traffic of Hue City (see § 4.1.8). Emission of exhaust gases related to the Project implementation during the work period will stay by far lower to that caused by car traffic in the main streets of Hue City. No significant health or ecological concern is expected to arise from this exhaust gases at any worksites. By contrast, in dry and calm wind period dust emission may affect the welfare of the population located in the close vicinity of worksites.

Mitigation measures

Vietnamese regulation comprises national standard for ambient air pollution (TCVN 5ç37:2005). However, the standard values for pollutants associated with transport such as NO_2 and particulate matter are likely to be exceeded in urban areas. Moreover, measurement of air pollution in the vicinity of mobile sources (vehicles and machinery) is not relevant to assess health impact because concentrations may vary to a large extent within very short periods and these values do not reflect the exposure of the general population. Since no significant air pollution by exhaust gases is likely to occur in worksites, it is recommended to restrict air monitoring to (large) dust concentration, through TSP (total suspended particles) measurement.

, will be likely continuous monitoring of noise and vibration level would be technically difficult, especially on “moving work sites”. Moreover, exceeding standard values is sometimes not avoidable for certain works, especially in urban zones where the basic noise level is already high, and monitoring cannot be considered as an actual prevention measure.

In residential areas trucks carrying earth, sand or stone will be covered with tarps to avoid spilling. Moreover, in these areas and out of the rainy days, water or wetting agents will be sprayed on work sites not covered by pavement or vegetation and during the delivery and handling of dusty materials.

5.3.1.3. Impact on soils

Loss of natural soil

Loss of natural soil will occur for different types of work, notably:

- excavation for laying pipes (trench digging). Since the vast majority of the water pipes will have a diameter less than 400mm, it can be assumed that on average 2 m^3 of soil will be excavated to lay a 1 m long pipe section. For a total of 400 km, about 800,000 m^3 of soil will be removed for upgrading the water pipe network. On the other hand, a part of the excavated soil will be used for backfilling the trench if the quality of the excavated soil is compliant with geotechnical standards. A maximum of 50% of excavated soil can be recovered for backfilling, reducing the net excavation of soil to 400,000 m^3. It is noteworthy that the trench will be filled back with a sand layer and adequate filling material which will need to be taken from remote borrow sites.

- scouring, earthworks and levelling for setting up WTP, booster station and raw water pumping station. Soil volume affected for pumping and booster station will be moderate (few hundreds m^3/facilities). According to HUEWACO the surface occupied by new WTP will amount to 109,000 m^3. Assuming that on average 1m^3/m2 will be excavated and not reused, a total of 109,000 m^3 of soil will be removed on WTP sites.

Pollution of soils

Soil contamination by spills of hazardous material may occur if oily products from engines are spilled along the outfall route due to improper disposal of used oils, lubricants or waste. The surfaces and volumes of soil likely to be affected by these kinds of spills are rather limited.

Mitigation measures

As much as possible the extracted material will be reused for backfilling trench open for water pipes and levelling sites of DWP and booster station. If the quality of extracted earth is not compliant with that of backfilling material (clayey material for example), treatment with cement or other way to improve material quality will be proposed by the contractor to HUEWACO.

All sand and selected material brought to the worksites by the contractor will have to be extracted from borrow sites authorized by the environmental authorities. Extraction of beach sand will be strictly forbidden.

Deposit of spoil material on public land shall be done on sites authorized by the environmental authorities. In any case, stockpiles of spoil material will not be prone to heavy erosion or natural transport by gravity or water runoff. Disposal of spoil material in any water course, water body or marine water is strictly forbidden.

Hydrocarbon storage areas and refuelling areas must be concrete made and located away from any watercourse. Tanks above ground must be placed on a watertight concrete made area and fitted with a retention basin. On-site fuelling and greasing will be restricted to heavy machinery, trucks and vehicles being fuelled and maintained is dedicated areas); all precautions will be taken to avoid any spillage. In case of spillage, the oil/fuel patch will be covered by sand and removed to be disposed into adequate landfill. In any case, fuel and lubricant can be stored in containers more than 100 l within 100 m of a watercourse or a water body.

The contractor shall place proper containers within the construction camp and permanent work sites in order to collect all kinds of common solid waste such as: glass, paper, cardboard and plastic waste and packaging. Common waste will be transferred to the containers of the company responsible for general domestic waste collection or by the contractor towards a dumping site which is formally used for domestic waste.

Special waste such as batteries, oil filters, etc., shall be collected in special containers proof for any leakage/spillage of toxic liquid/solids. If not recycled, they will be conveyed to adequate landfill dedicated to hazardous waste.

5.3.1.4. Impact on fresh waters

Pollution of fresh waters

Construction or upgrading the water intakes (raw water pumping station) may cause river pollution by release of polluting substances (fuel and lubricants) or discharge of spoil material (earth). This may also happen when constructing a WTP, this facility being most often located close to a water course to ease discharge of treatment sludge and filter backwash waters. The frequency and magnitude of these voluntary or involuntary events should be limited and the significance of resulting impacts will result of the feature of receiving watercourses. Accordingly large and very turbid rivers such as Huong River, Bo River and O Lau River are not likely to be affected whereas small, clear water courses such as Khe Su River (Loc Tri WDP) may be more vulnerable to this pollution, but only for a limited period.

Mitigation measures

See all measures for mitigation soil pollution (spoil material disposal, management of hydrocarbons and solid waste).

5.3.1.5. Impact on lagoon and marine waters

Pollution of lagoon and marine waters

Due to the high dilution rate of soluble substances and the settling of suspended particles, the limited pollution which may affect the rivers during the work period should not significantly affect the quality of lagoon or nearshore waters.

Mitigation measures

See all measures for mitigation soil pollution (spoil material disposal, management of hydrocarbons and solid waste).

5.3.1.6. Impact on terrestrial flora and ecosystems

Destruction of terrestrial flora and damage to preserved ecosystems

Terrestrial will be destroyed together with supporting soil. Laying 400 km of water pipes is assumed to cause destruction of on average 400,000 m* 2 m = 80 ha of vegetation and preparation of WTP sites is likely to destroy around 11 ha of vegetation. Density and ecological interest of cleared vegetation is very diverse according to the site: urban vegetation, meadow and agricultural crops, planted forest (cajeput or pine trees), secondary natural forest and primary forest. By chance, only little surface of natural forest is likely to be damaged for the purpose of the Project. Once again, it is worth noting that none of project infrastructures is located in a strictly protected area. Only the water intake of Loc Tri WTP (Khe Su River) is located within the Bach Ma National Park, but in an area dedicated to tourist and administrative activity. The Loc Tri WTP itself is located in the buffer zone of the Park, along the same river but nearly 2 km downstream of the intake (see Fig. 9 § 4.2.5). Both Loc An intake and WTP are located along Truoi River, downstream of the dam in the buffer zone of Bach Ma National Park.

Mitigation measures

Clearing must be done manually by the contractor. Cutting trees above 4 m high or with aesthetic value shall request authorization of the Supervisor.

In residential or suburban areas, all roadside or adornment trees felled for the Project will be replanted at the same site but in such a way that the roots of the new tree will not likely to damage the buried pipe. Trees preserved beside the pipe routes will be protected by temporary fences.

Construction of the water intake of the Loc Tri DWT and the raw water pipe section located within the core territory of the Bach Ma National Park will be done under the control of the Park management staff to whom a specific detailed design project will have to be submitted for approval prior starting the works. The specific detailed design will indicate accurately the location of water intake, the route of the raw water pipe, the surface to be cleared and the big trees to be felled. This document will described all the equipment and staff involved in the works and in the operation of water intake. A gauging campaign will be done prior to the works to make sure that the water abstraction will leave in any season an "environmental flow" deemed acceptable by the Park authority and the downstream population.

To compensate global destruction of soil and vegetation, it is proposed HUEWACO to replant trees on a surface of 200 ha, i.e. approximately twofold the scoured surface. This plantation will be done if possible in public/community area, for example in buffer zone or the forest restoration zone of a protected area such as Bach Ma National Park or Phong Dien nature reserve. Arrangements will be made with the Provincial Forestry Service in order to determine species to be planted, most appropriated areas to be planted and other modalities. If possible, plantations will be made by local communities through skilled NGOs and under the supervision of Forestry Service.

5.3.1.7. Impact on terrestrial fauna

On work site, displacements of vehicles and operation of machinery will generate disturbance for macro-fauna (birds, rodents, reptiles) and destroy meso-fauna and micro-fauna (insects, worms, etc.). No species of interest (protected, rare or endangered) is likely to be affected by these activities.

Mitigation measures

Mitigation measures aiming at reducing and compensating impacts on terrestrial flora and ecosystems (see § 5.3.1.6) should also mitigate impacts on terrestrial fauna

5.3.1.8. Impact on aquatic ecosystems

In case of spillage of polluting substances or discharge of spoil material, the aquatic fauna may be affected for a short period. However, for the vast majority of rivers, both dilution and flow will shortly restore the initial physicochemical features of the biotope, in such a way that prevailing flora and fauna communities will quickly recolonize it. The perturbation may however be more significant for small streams like the Khe Su River (Loc Tri WTP), especially if the works occur in the low water season. No significant impact on the ecology of lagoons and nearshore waters may be expected as a result of works.

Mitigation measures

Mitigation measures aiming at reducing impacts on fresh and marine water (see § 5.3.1.5) should also mitigate impacts on aquatic ecosystems.

5.3.1.9. Impact on human environment

Damage to private goods

Since the places where WTPs, booster stations and water pumping stations will be constructed either are owned by the State or will be acquired by HUEWACO, damage to private goods are not likely to occur in these sites. However, since long sections of water pipe will follow roads or urban streets, some private goods such as fences, walls, boreholes, etc., which have not been expropriated in the framework of the resettlement plan, may be involuntarily damaged during the works. The occurrence of this kind of damage should stay very weak if the works are attributed to skilled contractors.

Damage to public goods

Like the above mentioned private goods some public or community goods, including cultural/religious goods such as old pagodas, ancient relics may be involuntarily damaged by the vehicles and machinery working for the Project. The occurrence of this kind of damage should stay very weak if the works are attributed to skilled contractors.

Disruption to public services

For technical and/or safety reasons the public networks such as water supply, power and telecommunication (telephone wires) will have to be cut off for a short period around the work sites. If the served population is not informed, negative impacts may arise from this disruption. Likewise, accidental damage to an existing network (buried or aerial) may cause significant impacts.

Disruption to road traffic

The new pipe network will have to cross some roads and urban streets. Out of crossing point, the trench will be mostly dug alongside the carriage way, on the road shoulder. For these reasons, disruption to road traffic and narrowing of the carriage way will frequently occur during the laying of water pipes. In this case, the magnitude of impact will be linked to the usual traffic of the concerned roads and streets.

Adverse effects on health, welfare and safety of the nearby population

As stated above, welfare of population leaving in the close vicinity of work sites, especially where the water pipe will be laid, will be affected by noise, vibration and dust emitted by contractor's vehicles and heavy machinery. Furthermore, movements of vehicles and machinery as well as poorly or not signalized excavations or stockpile of material may increase the risk of accidents among the population crossing the work sites on foot or by two and four wheel vehicles.

Mitigation measures

The contractor shall assume all responsibility to locate or to confirm the details and location of all private and public goods likely to be affected by works and exercise the greatest care at all times to avoid damage to or interference with these goods.

The contractor shall assume responsibility for any damage and/or interference caused by him or his agents, directly or indirectly, arising from actions taken or a failure to take action, and for full restoration of the damage at his own expenses.

The contractor shall take into account in his program the periods required to locate access, protect, support and divert public services, including any periods of notice required to do such work in consultation with local owners, population and authorities operating such services. The contractor shall then take all measures to avoid damage to or interference with public services and assume responsibility for any damage and for full restoration of the damage. When working in the vicinity of overhead power cables, the contractor shall ascertain and satisfy himself about the safe clearances to be maintained from the power cables in consultation with the authority operating the power line.

As much as possible, the contractor shall ensure the continuity of the road traffic. If traffic interruption is necessary, the information of the concerned population shall be ascertained by the contractor with a proper schedule in order to attenuate disturbance.

After laying pipe and backfilling the trench with adequate material, all the damaged surface of carriage ways and sidewalks shall be restored in accordance to the relevant Vietnamese standards, even if these infrastructures did not meet these standards before the works. This restoration will include proper road drainage system. Restored infrastructures will be inspected and validated not only by the supervision team but also by road authorities.

The contractor shall enforce speed limit for its vehicles and those of its sub-contractors. The recommended speed limit is of 40 km/h inside residential areas and 50 km/h outside residential areas.

The Contractor shall ensure the safety of the users of roads bordered or crossed by the work sites. With this aim, he shall provide the supervisor with a written and clear traffic control plan which is to include when and where flagmen shall be employed and when and where traffic cones or other devices such as barricades and/or lights will be used. All the work sites on or in the close vicinity of roads shall be properly signposted with adequate marks and tools such as cones and coloured bands. If pedestrians have to walk on the carriage way because of the work, specific pathways will be delineated and protected by adequate fences. Access to private houses, shops and all commercial public buildings shall be preserved by the means of safe footbridges.

For the record, measures against noise, vibration and air pollution will be implemented to mitigate impacts on health and welfare.

5.3.2. DURING OPERATION PHASE

5.3.2.1. Impact on soil

Soil erosion

If large-diameter water pipe is laid on a slopped land occupied by natural vegetation or planted forest, the scoured strip which will stay above ground will be prone to erosion by the runoff of rain water. Then, if the slope is steep, notable loss of soil may occur, digging a new trench more and more deep and wide. For moderate slopes, the quick colonization of the scoured strip by herbaceous vegetation will slow down and finally stop this process.

Mitigation measures

Out of strictly urban areas, all the backfilled trench sections which will not restored as roads, tracks, footpath or sidewalk will be planted with herbaceous species. Species used for plantation shall show the following features, in order of decreasing importance: autochtonous introduced to Vietnam since more than 50 years ago, not known as intrusive in the surrounding ecosystem, adapted to ecological conditions, rapid growth and strong covering power, shallow root system, not grazed by cattle. The width of the planted strip will at minimum equal that scoured for the purposes of the Project. It is presently difficult to estimate the total surface which will need to be so planted, but just a moderate part of the network should be concerned. At a rough guess it can be assumed that the surface will not exceed 100 km * 5 m = 50 ha.

5.3.2.2. Impacts on fresh waters

Decrease of river flow due to raw water abstraction

In the Project area raw water abstraction is not likely to vary significantly over the year which is not the case of the river flow which is closely linked to the rainfall. Accordingly, given the climatic features of the TTH province, the ratio abstraction flow/river flow may vary considerably according to the season. Accordingly the remaining flow downstream of the intake may reach a very low value not sufficient for the river to fulfil its usual functions with respect to ecology (preservation of aquatic wildlife) and socio-economic resource (navigation of local boats, fishing, irrigation, etc.). In the worse case, the river bed section downstream of the intake could nearly dry out as long as the water of the next tributary will run in it.

As a matter of example, the cumulated abstraction of Huong River water in 2020 (Quang Te 1 and Quang Te 2 WTP) will be around 162,000 m^3/day, which accounts for 2 % of the average flow of the river (200 m^3/s) but for 40% of its lower flow i.e. 10 m^3/s (value exceeded for 99.9% of time at the water level gauge located 300 m downstream of Van Nien). As far as the Bo river is concerned the abstraction of 12,000 m^3/d by the intake of Tu Ha DWP will only account for less than 3% of the lower flow (5 m^3/s, value exceeded for 99.9% of time at Co Bi station). Likewise, abstraction of water from O Cau River by both Hoa Binh Chuong and Phong Tu WTPs should not be a concern. Higher concern could arise from abstraction of medium and small size rivers, the regime of which is not yet known such as Nong River (Loc Bon WTP), Truoi River (Loc An DWP) and Khe Su River (Loc Tri WTP). It is however clear that the raw water abstraction will not significantly influence the hydrological regime of downstream lagoons forming the Tam Giang-Cau Hai system.

To mitigate this kind of impacts, environmental legislation of many countries requires for facilities such as dam or water intake to release or leave an “environmental flow” of water with a view to maintaining downstream ecosystems and their ecological and socioeconomic benefits. In France, for example, the environmental flow equals 10% of the average flow of the river but this value cannot be applied to rivers experiencing huge variations in flow like rivers of TTH Province.

Pollution of fresh water by discharge of treatment sludge

Pollution of freshwater will result from discharge of water treatment sludge into a water course, usually into the river which provides the raw water but obviously downstream of the water intake. Sludge are constituted of both suspended matter initially existing in the abstracted raw water and flocculating agent which is Polyaluminum Chloride (PAC) for all the WTP operated by HUEWACO except Phu Bai WTP (groundwater) and Bach Ma (very clear torrent water).

PAC in its solid form (yellow powder) contains 30% of Al_2O_3 i.e. 16% of elementary aluminium (Al). Aluminum is known to be toxic for aquatic life (fish and invertebrates) but its toxicity is linked to its solubility, the most toxic form being the soluble Al^{3+} form which can be easily absorbed and metabolized by organism. Adverse effects of aluminum on neurological functions of mammals and human beings as also been demonstrated (UE acceptable concentration in drinking water: 0.2 mg Al/l) but not carcinogenicity. However, soluble Al^{3+} ion is only predominant in acidic water (below pH 4.0). Between pH 5.2 and 8.8 the insoluble (hence far less toxic) form $Al(OH)_3$ largely predominates. Since surface waters of the TTH Province show pH value very close to the neutrality (between 6.9 and 7.1), the concentration of Al^{3+} and its release from insoluble aluminium compounds is extremely low. Moreover, Al does not accumulate to a large degree in fish and shellfish. It should be also remembered that aluminum is the most abundant metallic element in the lithosphere, comprising about 8% of the earth's crust. Aluminum constitutes the main part of clay minerals and its oxide and hydroxides are very likely to be naturally abundant in soils of TTH province and that the soils and water sediment of TTH Province are very rich in insoluble aluminium oxides and hydroxides which are hence present in river sediments.

Based on HUEWACO data, the quantity of PAC used by the Quang Te 2 DWP (Huong River) is on average 8g/m^3 of treated water. So, according to the Project figures, the total quantity of aluminium involved in the treatment in 2020 would amount to 8g * 16% * 260,000 = 332,800 g/d = 3.85 g/s. In the worst case, this quantity is totally discharged through sludge in the extreme low water season: i.e. upstream flow = 10 m^3/s, raw water abstraction = 4 m^3/s, remaining flow = 6 m^3/s, resulting in an aluminum concentration in receiving water of 3.85/6 = 0.6 g/m^3 = 0.6 mg/l. If all the aluminium was in Al^{3+} form, this concentration would be of real concern because for example, the Lethal Dose 50% for brown trout is only 0.3 mg Al/l. But at pH 7.0 usually observed in river waters of the TTH Province, the soluble Al^{3+} form accounts for less than 0.1% of total aluminium, which lowers the concentration of Al^{3+} below ecotoxicological thresholds. This can also explain why mortality event of aquatic macro-organisms has never been reported downstream of aluminum sludge discharge point.

Other concern associated with the discharge of treatment sludge is the increase of turbidity of the receiving water course. The sludge dry solids is mainly comprised of the flocculated water suspended solids, the insoluble compounds of the added aluminium, some coagulated organic compounds (fulvic acids) and other insoluble compounds of iron and manganese. Generally, the added suspended matter does not exceed the existing one by more than 50%, so since the water flow is usually by far higher than the discharge flow, the turbidity does not significantly increase at the discharge point. However, the Vietnamese standard TCVN6489: 2001 stipulates that the effluent discharged by an industrial facility into a river should have a suspended matter concentration less than 100 mg/l to protect aquatic life. After decantation the treatment sludge has often nearly 1000 mg/l of dry solids. Accordingly, if the Vietnamese standard TCVN6489: 2001 applies in the case of a WTP, which does not seem to be clear, the discharge of treatment sludge is not allowed by law.

Until now, all the treatment sludge produced by the WTP in TTH Province have been discharged into rivers, however, at Quang Te site, HUEWACO is being constructing drying beds to dehydrate the treatment sludge produced by current and future Quang Te DWPs. HUEWACO also initiated discussions with potential users of the dewatered sludge (brick factories, public works companies).

In conclusion, if the discharge of drinking water sludge is not likely to cause significant impacts on ecosystems and human health in the short and medium term, this cannot be considered as a sustainable way to manage this by products, all the more since this sludge is likely to end up to the Tam Giang-Cau Hai lagoon complex which is critical for the local economy based on seafood production and under way to be classified as a protected area with the support of ADB. As a result, the HUEWACO's initiative for constructing drying beds in Quang Te deserves to be replicated at least for the main WTP located not to far away from valorisation unit.

Mitigation measures

Actually it is difficult to mitigate impact of lack of water downstream of a water intake in another way than compensation for the loss of biodiversity or the loss of income by the riparian populations. So prior to decide to set up a water intake in a small stream it is critical to assess the extent to which the water abstraction, especially in low water season, is likely jeopardize the ecological and socioeconomic services given by the river downstream. With this aim it is proposed to carry out Environmental Flow Assessments (EFA) for the new WTPs using raw water from medium and small size rivers, i.e. Loc Bon (Nong River), Loc An (Truoi River) and Loc Tri (Khe Su River). These EFA will aim to determine the extent to which the water abstraction, especially in low water season, is likely jeopardize the ecological and socioeconomic services given by the river downstream of the intake. Each environmental flow assessment will be carried out by a team constituted of three national senior experts: a hydrologist, a hydrobiologist and a sociologist. A total of four person-months is anticipated for the completion of each EFA.

The current discharge of treatment sludge generated by an aluminum compound (polyaluminum chloride or PAC) into rivers is not sustainable, although not really harmful in the geochemical context of TTH Province, all the more so since a part of this sludge is

likely to settle down in the Tam Giang – Cau Hai lagoon complex. Moreover, dry solid content liquid sludge do not complies with standards for discharge of industrial effluent into rivers. If this practice should cease, two problems are to be worked out which are (i) the treatment and (ii) the final outlet of sludge. Treatment of drinking water sludge, which is stable matter, basically aims to reduce water content with the view of decreasing the volume and the weight of sludge as well as easing sludge handling. Dewatering can be made mechanically or not, with or without addition of polymer or lime. Mechanical dewatering is expensive and needs the sludge to be thickened first. Use of drying beds (sand layer fit with drains) remains the more appropriate solution when sufficient space is available within the WTP premises. This technical option is being implemented in Quang Te. Even more basic and cheap option would be dewatering by evaporation in lagoons, but it requires lot of space and is not suitable for rainy climate. Potential outlets for drinking water sludge are diverse:

- discharge of raw drinking water sludge to Wastewater Treatment Plant (WWTP), through sewer or by road transport, cannot be envisaged currently because there is not yet WWTP in TTH province
- disposal of dewatered sludge onto a sanitary landfill is a common practice but the cost of transport and the increasing landfilling fees make it more and more expensive. However the Thuy Phuong landfill is not too far from Quong Te, Loc Bon, Loc bon and Binh Thanh.
- other, more sustainable possible outlets are reuse of sludge as raw material in civil works (material for embankment) and in construction material (cement factory, brick factory). However, this kind of reuse is often studied in theory but very rarely implemented because companies are often reluctant to work with this material they do not know and when they agree to use it, they most often refuse to pay for it, even just pay for the transport cost.
- spreading of drinking water sludge on agricultural land has been made in some countries but this kind of sludge does not have value as fertilizer or soil conditioning agent. Moreover, aluminium has a great affinity with phosphorus and may in certain conditions, decrease the availability of this nutriment for crops.

It is proposed to install drying beds in the WTP of more than 10,000 m^3/d with a ratio of 1 m^2 surface for 100 m^3 of produced drinking water i. e. Phong Tu WTP (210 m^2), Tu Ha WTP (120 m^2), Loc Bon WTP (300 m^2) and Loc An WTP (120 m^2). In addition, a study will be carried out to assess all relevant outlets for drinking water sludge (including landfilling) within the TTH Province and define a strategy for environmentally and economically sustainable disposal of drinking water sludge produced by HUEWACO. This study will be carried out by an environmental engineer and will require three person-months.

5.3.2.3. Impacts on landscape and sceneries

Aesthetic damage o pleasant landscape

Drinking water treatment plants and water intake are set up beside or in the close vicinity of rivers, some times in pleasant landscape. Since the TTH Province has significant incomes from national and international tourism, and is willing to develop this sector, it would be desirable for the water facilities to be constructed in such a way that the surrounding landscape/prevailing architectural style is not aesthetically damaged. This also applies for booster stations and water tanks which may also be imposing buildings. If obviously the investment priority should be given to the technical aspects ensuring drinking water quality rather than to the architectural ones, some works of moderate cost such as adequate painting or facing as well as site landscaping or more simply tree hedge planting can very likely improve the look of water facilities. However, it is noticeable that most the WTP operated by HUEWACO are reminiscent of traditional Vietnamese large houses.

Mitigation measures

Landscaping works including tree plantations will be undertaken for embellishment of new facilities built by the Project, i.e.Phong Tu WTP, Tu Ha WTP, Loc Bon WTP, Loc Anh WTP and Loc Tri WTP as well as the seven new booster stations.

6. ANALYSIS OF ALTERNATIVES

6.1. NO PROJECT ALTERNATIVE (DO-NOTHING)

Under the do-nothing alternative, there will be no possibility to meet the water demand of the population of the TTH province, especially out of Hue City. Accordingly, the high incidence rate of waterborne diseases such as diarrhoea or dysentery (see § 4.4.2) will continue to affect population, especially in rural areas. It should be reminded that particularly vulnerable populations such as indigenous peoples (ethnic minorities) and boat people are currently particularly at risk with respect to health adverse effect associated with lack of potable water.

6.2. STRATEGIC ALTERNATIVES

The strategic option developed in terms of resource mobilization consists in abstracting and treating waters of many independent rivers rather than concentrating production from a small number of big rivers (Huong River and Bo River, for example). This strategy is suitable to protect production of clean water for an accidental pollution event and also to limit possible ecological and socio-economic impacts of a too high abstraction rate on the downstream stretch and surrounding areas. It also prevents environmental impacts which will result from laying down a huge pipe water network.

Mobilization of groundwater for drinking water production may only be envisage in the plan and coastal areas where the water table is not too deep and the aquifers more productive, but these resource are vulnerable to salt intrusion and the raw groundwater is not of very good quality (low pH, high content in dissolved salts and iron). The sole DWP which treats groundwater (Phu Bai WTP) will however be kept operating at its current capacity according to the Project.

6.3. TECHNICAL ALTERNATIVES

The surface water treatment process is based on coagulation/flocculation with poly-aluminum chloride (PAC), sand filtering and disinfection by chlorination, either with gaseous Cl_2 (most often or bleach for small size or remote WTP. In some cases, according to the raw water quality additional treatment are preformed such as pre-chlorination, activated carbon or UV. Albeit very effective for the destruction of germs, the chlorination of surface waters is more and more often criticized for the possible generation of toxic compounds such as trihalomethanes (THMs) by combination with organic substances contained in raw water. The higher the water contents organic matters such as fulvic acids naturally occurring in soils, the higher quantity of THM will be generated by chlorination. At their usual concentrations in drinking water, THM are not likely to cause short-term effects but many of them are carcinogenic and thus may increase the cancer risk after long term exposure. Actually, the risk excess is very weak and chlorination remains the way of disinfection by far the most widespread over the world including in rich countries. The decision taken by HUEWACO to use PAC rather than more usual and less expensive coagulant/flocculant such as aluminum sulphate (alum) appears to be very wise in terms of public health because PAC is more effective for removal of suspended matter but also for removal of fulvic acids and other organic compounds. Moreover, flocculation with PAC produces less sludge than that with alum, and thus can be considered more sustainable..

7. PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

Human impacts generated by the Project implementation will depend on the magnitude of the works (linked to the number of involved vehicles and machinery, the volume of earthworks and so on) and the population density in the vicinity of work sites. For example, laying pipe less than 200mm in diameter, which accounts for more than 70% of the total pipe length, is not likely to cause heavy impacts for nearby population, but the impacts may be significant for a pipe of more than 1000 mm in diameter, which only account for less than 1% of total pipe length (nearly 6 km). Detailed design of project was not fully completed at the of the consultant's mission but by this time, three formal public consultations have been hold at the following places:

- Quang Te (part of Hue City) on the 1st December 2009
- A Luoi on 15th December 2009, and
- Nam Dong on 17th December 2009

These three locations were actually priority because they cumulate high intensity of works (construction of WTP and large size distribution network, including the only sections of 1200mm and 1500mm pipes) and the high population density (urban areas)

During these meetings, the environmental aspects have been exposed together with resettlement issues. First the Project was presented with its strategic framework and specific objectives, its main features in terms of location, technical components and then the layouts of detail design in order to clearly show the impacted streets and areas.

Presentation of environmental aspects was comprised of:

- the main biophysical impacts and human impacts likely to arise during the Project implementation, especially in construction stage
- the measure anticipated with a view of mitigating these impacts
- the indicators that will be monitored during both construction and operation phases.

No matter of concern has been clearly expressed in the comments of the present affected people. Generally speaking, people considered that improvement of water supply is so critical that they can accept to face shortcomings associated with construction phase, all the more since the main expected impacts are properly mitigated.

8. GRIEVANCE REDRESS MECHANISM

In its new Safeguard Policies Statement date June 2009 ADB requires that the client establish and maintain a grievance redress mechanism to receive and facilitate resolution of affected peoples' concerns and grievances about the client's social and environmental performance at project level. Moreover, the grievance redress mechanism should be scaled to the risks and impacts of the Project. It should address affected people's concerns and complaints promptly, using an understandable and transparent process that is gender responsive, culturally appropriate, and readily accessible to all segments of the affected people.

Unlike grievance redress mechanism developed with respect to resettlement procedures which is under responsibility of People's representative bodies such as Ward or Commune's People's Committee, the grievance associated with social and environmental impact of the Project will directly managed by HUEWACO. Actually environmental and social impacts of the Project will be caused either by the contractors appointed by HUEWACO during construction phase or by HUEWACO operational services (in charge of WTP, other facilities and water networks) during operation phase.

It is recommended that a Grievance Unit be set up within HUEWACO's Customer Care Service Department. The complaints made by Affected People (AP) will be lodged with Grievance Unit (GU) by written letter or phone call (hotline). Both Grievance Unit's address and hotline number will be clearly indicated in all worksites during construction phase (including mobile pipe laying works) and at each constructed/extended standing facility (DWP, water intake and booster station) during the operation phase).

As soon as a complaint will be lodged, it will be registered by the GU and the AP will be sent an acknowledgement of receipt with a grievance reference number.

For damages caused by a contractor in construction phase, HUEWACO will organized a meeting with the AP, the contractor's representative (Site manager) and the head of the Supervision team within 15 calendar days from the date of complaint registration. Environmental officers from both contractor and supervision team (see below) will also attend this meeting. During this meeting, a solution of grievance redress will be proposed to the AP and recorded in a minute report signed by the contractor, supervisor and the AP. A formal grievance redress document in accordance with the minute report will be then officially sent to the AP under cover of HUEWACO. This document will indicate the agreed solution and its features (financial compensation, nature compensation, restoration works, etc.) and the delay for implantation will not exceed 20 calendar days from the date of meeting.

For adverse impacts occurring during operation phase (for example, lowering of water level of a river use for fishing due to water intake), the grievance redress mechanism will be addressed by the HUEWACO's involved staff (management staff of a given WTP, for example). After meeting with the AP, a solution will be elaborated and officially sent to the AP. It will be the responsibility of the HUEWACO to resolve the issue within 4 weeks from the date the complaint is received.

If the AP is not satisfied with the proposed solution or in the absence of any response within the stipulated time, the AP as a last resort may submit his/her case to the District Court. Beyond this the AP may lodge their complaint to the Operations Department or the Office of the Special Project Facilitator (OPSF) in accordance with ADB Policy.

During the construction phase, the Supervision team, through its Environmental supervision officer will be responsible for checking the procedure and for and resolutions of grievances and complaints. This will have to be recorded as part of final supervision report triggering the deliverance of Taking Over Certificate.

In addition, as part of the Project's internal monitoring and evaluation, HUEWACO will keep a written record of all grievances and complaints brought forward by APs, as well as

their final resolution for both construction and operation phase. This is however required for ISO 14001 certification.

HUEWACO will be responsible for ensuring that all APs will be made fully aware of their rights, for publicizing the detailed procedures for filing grievances through effective public information campaigns.

9. ENVIRONMENTAL MANAGEMENT PLAN

9.1. IMPLEMENTATION ARRANGEMENTS

9.1.1. THE ENVIRONMENTAL MONITORING UNIT (EMU)

The Consultant recommends the creation of an **Environmental Monitoring Unit** (EMU), a multi-sectoral committee which will be responsible in coordinating and supervising the implementation of all recommended environmental measures and in assessing in a **proactive manner** the environmental impacts of the Project.

The EMU will be constituted of:

- the Deputy Director of HUEWACO, Chairman
- a representative of the Department of Natural resource and Environment (DONRE), Vice Chairman
- the Senior Environmental Consultant (SEC, see below § 9.1.2), Secretary
- the Internal Environmental Officers (IEO, below § 9.1.2),
- a representative of the Department of Agriculture and Rural Development (DARD)
- a representative of the Department of Public Health (DOPH)
- for each (major) work contract
    - the Head of the Construction Supervision team, during the outfall construction stage
    - the Environmental Supervision Correspondent (ESC, see below § 9.1.3.2), during the outfall construction stage,
    - representatives of the concerned Commune People Committees

If the need arises, other persons and institutions, such as the Chief of Bach Ma National Park, Management Board of Huong River Projects, Department of Tourism, professional organisations, thematic experts, etc., may be asked to take part in the meetings of EMU.

The EMU shall be officially established before the elaboration of bidding documents in order to verify the incorporation of the environmental requirements.

The main tasks of the EMU will be the following:

- check that the measures related to the good environmental practices (environment requirements) and the additional works are incorporated in the tender documentation and in the contract documentation
- elaborate, validate the environmental requirements and incorporate them into the bidding documents for both Contractor and Supervisor
- ensure, with the help of the Supervision consultants, that the mitigation measures are properly implemented by the contractor during construction.
- review works reports, and notably environmental related chapters
- notify HUEWACO of any noticed breach of implementation of mitigation measures (notably environmental practices) by the contractor. In this case, the EMU should propose to HUEWACO adequate remedial measures to be undertaken by the contractor or the institution in charge
- approve the report of environmental acceptance of works

- review and approve monitoring reports (monitoring stage). In case of unexpected impacts, the EMU could suggest remedial measures to the concerned Authorities.

The EMU will be operating from the bidding stage and keep on being active during three year from the end of the last construction/extension works. The EMU should meet at least **every 6 months** during the construction stage and **every year** during the following three-year phase. However, on a justified request of any member, extraordinary EMU meetings might also be held.

9.1.2. RESPONSIBILITY, TASKS OF HUEWACO, ENVIRONMENTAL CAPACITY BUILDING

HUEWACO is the delegated Executing Agency of the Project. As a Vietnamese company, it should ensure compliance of the Project with the national policy and regulations related to the protection of the environment. By the nature of its activity, HUEWACO is also due to protect health of all its customers be delivery a safe drinking water. Since the present Project is likely to impact negatively the environment, the duty of HUEWACO is to ensure that environmental concerns are addressed at every stage of the Project, i.e. feasibility (i.e. present stage), design, construction, and operation.

In the short term, HUEWACO shall ensure that EIA findings are properly taken into account by the supervision consultants and the construction contractors. HUEWACO shall also directly contract or come to arrangements with relevant operators to undertake environmental measures which cannot be implemented by construction contractors.

Once the facilities are properly built, HUEWACO shall ascertain the adequacy of the mitigation measures issued by the EIA and implement an impact monitoring plan, as it is set out in detail below in this report (see § 9.3).

It seems that HUEWACO has no staff skilled in environmental management. It has no environmental service or environmental focus point. By contrast, the Water Quality Management Department, located in Quang Te WTP office, is comprised by staff well specialised in water sampling and analysis who are involved in quality monitoring of both raw and treated water produced by all WTP operated by HUEWACO. Actually to date, among the facilities operated by HUEWACO, only two have been subject to environmental assessment: Hoa Binh Chuong in 2005 and Quang Te 2 in 2008. The EIA have been outsourced. Other facilities were constructed before enactment of the environmental laws. The ISO certification study carried out in the framework of the present PPTA reveals that (i) HUEWACO has not established an environmental policy, (ii) the significance of Environmental Aspects and Impacts have not been evaluated within HUEWACO and (iii) that environmental legal and other requirements relating to HUEWACO operations have not been identified.

It results of the previous finding that the environmental management capacity of HUEWACO is to be build and that the present “multi-site” water supply project at the scale of the entire TTH Province would be a good opportunity to initiate the environmental capacity building process. With this aim it is proposed HUEWACO to recruit through a consulting firm an external **Senior Environmental Consultant (SEC)** who will work together with one or (preferably) two **Internal Environmental Officer (IEO)** forming part of HUEWACO technical staff. The main duty of the SEC will be to supervise environmental management of works as well as monitoring activities as described below (see § 9.2 and 9.3). However, in order to improve environmental management capacity of HUEWACO, training activities will be undertaken by SEC.

As far as environmental training is concerned, it should be remembered that the ISO 14001 certification study carried out in the framework of the present PPTA provides for a rather exhaustive training program on:

- ISO 14001 standards (Environmental Management) requirements

- environmental aspects- impact significance analysis relating to the operation of water treatment and transport facilities
- environmental internal audits

Other training activities are also planned on occupational health and safety management systems (OHSAS) and Hazard Identification Risk Assessment and Determining Controls (HIRADC).

Accordingly, in order to avoid interference/duplication with the above-mentioned training program, the training activities performed by the SEC will mainly focus on the management of construction works of water utilities and the approach will be mainly base on on-the-job and field training for the IEO.

The Senior Environmental Consultant will be an environmental specialist or a civil engineer preferably with postgraduate specialisation in environmental engineering. He will have at least 10 years working experience related to the integration of environmental and social issues in the design, construction and operation of infrastructure projects. Experience in construction management and operational maintenance of water facilities will be an asset.

The SEC will work with HUEWACO full-time for five years from the start of construction of the first WTP.

The IEO will be preferably young engineer(s) specialized in water infrastructure who will replace the SEC after his full-time 5 years-period. This PMU environmental team will have to:

- visit all the works in progress on the regular basis to inspect all environmentally sensitive worksites
- liaise with the supervision team, in particular with the Environmental Supervision Correspondents (see below § 9.1.3.2)
- liaise with DONRE and other relevant provincial administrations
- ease the process of grievance redress by meeting the affected persons and organizing meetings with concerned contractors
- participate to the monthly works meeting and validating environmental part of monthly works progress report
- supervise, treat and archives result of monitoring campaigns
- act as secretaries in the EMU
- draft PMU meeting minutes en quarterly environmental reports

The environmental team will be supplied with computers and one 4x4 vehicle.

In addition, the SEC will periodically make lectures to IEO and other management staff of HUEWACO about the following topics:

- environmental regulations associated with water facilities
- implementation of Environmental Management Plans
- environmentally sounds construction practices
- monitoring contractor’s environmental performance during construction
- long term environmental issues related to water supply project (quality of raw water, treatment by products, sludge treatment and disposal, etc.)

9.1.3. OTHER STAKEHOLDERS' RESPONSIBILITIES AND DUTIES

9.1.3.1. Responsibility and tasks of the DONRE (Provincial Department of natural Resources and Environment)

Through its Environmental Management Division (EMD) the Department of Natural Resources and Environment of the TTH Province (DONRE) is an administrative agency which regulates and provides guidance for the environmental management of the Province. The DONRE, inter alia, provides direction to project proponents on the requirements for conducting EIA according to the LEP (2005), and guidance on use of the environmental quality standards that are in place protect the environment. The EMD of DONRE is responsible to review and appraise EIAs that are prepared by proponents for all development projects that occur within the geographic boundaries of the TTH Province. Accordingly a representative of DONRE, preferably an OEM staff has been proposed to be the Vice-Chairman of the Environmental Monitoring Unit (see above § 9.1.1)

9.1.3.2. Responsibility and tasks the Supervision Consultants

For each major construction contract, the assigned Supervision Consultant shall make sure that the contractor properly implements the environmental requirements specified in the contract documentation and in the Contractor Environmental Management Plan (CEMP, see below).

Since the environmental supervision needs to be carried out on a daily basis, each Supervision Consultant team should include a part-time **Environmental Supervision Correspondent** (**ESC**).

The Environmental Supervision Correspondent (ESC) will be in charge of:

- liaison with the PMU environmental team: he will have to inform SEC and IEO as soon as he will observe a significant environmental non-compliance, damage or risk of damage due to the contractor.
- the establishment of linkages with the nearby population
- the approval of the Contractor Environmental Plan
- the monitoring of the contractor environmental practices. The ESC will be particularly responsible for approving the sites for disposal of spoil material
- the elaboration of the environmental chapter of the monthly works progress report
- taking part in Environmental Monitoring Unit

At the end of the works, the ESC together with the SEC and/or IEO shall carry out a final environmental audit of the works. The result of the audit will be taken into account for the final acceptance of the outfall construction works.

The ESC will have to be a full-time member of supervision team but he will spent one day a week for implementing his environmental tasks. He should be clearly designated among supervision staff in the contract documentation.

9.1.3.3. Responsibility and tasks of the Construction Contractor

All contractors should first be compliant in all their work sites and construction camps with the Vietnamese standards regulating environmental nuisances (noise, pollutants emissions, etc.), health and safety of workers and the nearby populations. Even if it goes without saying, this must be clearly mentioned in the contract. However the observance of standards does not prevent environmental damage without an environmentally sound behaviour of workers, foremen, engineers and managers.

For each construction contract, the contractor shall appoint one responsible member of his staff to act part-time as **Site Environment Health and Safety Officer (SEHSO)**, and he shall notify the Supervisor of such appointment. The SEHSO shall be experienced in all matters relating to environmental management, health and safety on work sites and facilities and shall be familiar with all relevant environmental and safety regulations and legislation in force in industrialised countries. The SEHSO shall have the power to receive instructions from the Supervisor on matters relating to the health and safety of personnel on sites and the environmental management of sites. The SEHSO shall also be involved in training of employees on environmental/safety practices and sensitization of population affected by the Project.

The Contractor shall propose the Curriculum Vitae of the SEHSO to the approval of the Supervisor within two months following the formal assignment.

In addition, and to avoid any ambiguity, the contractor (and more particularly the SEHSO), will be required to prepare, as soon as appointed, and before beginning building his construction camp, a **Contractor's Environmental Management Plan** (**CEMP**).

The CEMP shall include the following documents:

1) Accommodation procedures for employees (if required)
2) Health and safety procedures
3) Solid waste, fuel, lubricants and wastewater management procedures
4) Noise management procedures
5) Air quality management procedures
6) Road traffic management
7) Public and private utilities management procedures

All these procedures should comply with the environmental requirements included in the tender and contract documentation and shall be provided to the Supervision Consultant within two months following the formal assignment. Each contractor will be responsible for its sub-contractors to comply with its own environmental commitments.

9.1.4. ENVIRONMENTAL DOCUMENTATION OF THE PROJECT

According to the previous provisions, the environmental documentation of the Project will be comprised of:

- the present EIA report
- the environmental requirement to be incorporated in the tender and contract documentation
- the Contractor's Environmental Management Plan (CEMP)
- the environmental components of the Monthly Work Progress Reports
- all the letters issued by the Supervisor, the Contractor or HUEWACO pertaining to the environmental management of work
- the environmental acceptance report
- the monitoring reports
- the minutes of meeting of the EMU

All this documentation should be carefully archived by HUEWACO which will likely use it for environmental management of other future projects.

9.2. MITIGATION PLAN

The proposed mitigation measures described in § 5.3 are recapitulated Table 9.1a, 9.1b, 9.1c and 9.2.

Table 9.1a: Mitigation Plan of impacts potentially occurring in construction phase

Impact	Activity	Mitigation measure	Locations	Period	Responsible for Implementation	Responsible for Supervision	Means of Verification	Cost
Noise and vibration	Site cleaning / preparation Earthworks Construction works Equipment installation Pipe laying	The contractor shall: - use equipment conforming to national of international standards and directives on noise and vibration emissions - maintain exhaust systems in good working order, properly designing engine enclosures, using intake silencers where appropriate and regularly maintain noise-generating equipment - restrict working noisy activities between 07 a.m. to 17 p.m. within the residential areas - inform management staff of likely impacted schools and hospitals about the work program in order to find arrangements for limiting the nuisance	Within residential areas and protected area (Loc Tri)	Construction	Contractor	SEC/IEO + ESC	Non compliance statement in works monthly report	No marginal cost
		Compliance with national standards TCVN 5949:1998 and TCVN 6962:2001	Within residential areas and protected area (Loc Tri)	Construction	Skilled operator	SEC/IEO	Noise and vibration monitoring	See monitoring plan
Air quality	Site cleaning / preparation Earthworks Construction works Equipment installation Pipe laying	Machinery, vehicles and equipment will be fitted with pollution control devices, which will be checked at regular intervals to ensure that they are in working order In residential areas - trucks carrying earth, sand or stone will be covered with tarps to avoid spilling - water or wetting agents will be sprayed on work sites not covered by pavement or vegetation and during the delivery and handling of dusty materials.	Within residential areas	Construction	Contractor	SEC/IEO + ESC	Non compliance statement in works monthly report	No marginal cost
		Compliance with national standards TCVN 5937:2005 for Total Suspended Particles (TSP)	Within residential areas	Construction			TSP monitoring	See monitoring plan

SEC: Senior Environmental Consultant – IEO: Internal Environmental Officer (HUEWACO) – ESC: Environmental Supervision Correspondent (supervision team)

Table 9.1b: Mitigation Plan of impacts potentially occurring in construction phase (continuing)

Impact	Activity	Mitigation measure	Locations	Period	Responsible for Implementation	Responsible for Supervision	Means of Verification	Cost
Loss of soil	Site cleaning / preparation Earthworks	As much as possible the extracted material will be reused for backfilling trench and excavations. If the quality of extracted earth is not compliant with that of backfilling material (clayey material for example), treatment with cement or other way to improve material quality will be proposed by the contractor to HUEWACO.	On all work sites, especially laying of water pipes	Construction	Contractor	SEC/IEO + ESC	Non compliance statement in works monthly report	ESO/EJO + ESC
		All sand and selected material brought to the worksites by the contractor will have to be extracted from borrow sites authorized by the environmental authorities. Extraction of beach sand will be strictly forbidden.	On all work sites	Construction	Contractor	SEC/IEO + ESC		No marginal cost
		Deposit of spoil material on public land shall be done on sites authorized by the environmental authorities. Protection of stockpiles against runoff erosion.	Spoil material disposal sites	Construction	Contractor	SEC/IEO + ESC		No marginal cost
Pollution of soil, rivers and lagoon waters, adverse consequence to aquatic fauna	Site cleaning / preparation Earthworks Construction works Equipment installation Pipe laying	Disposal of spoil material in any water course, water body or marine water is strictly forbidden Hydrocarbon storage and refuelling areas must be concrete made and located away from any watercourse. Tanks above ground must be placed on a watertight concrete made area and fitted with a retention basin. On- site fuelling and greasing will be restricted to heavy machinery, all precautions will be taken to avoid any spillage. In case of spillage, the oil/fuel patch will be covered by sand and removed to be disposed into adequate landfill. No fuel and lubricant will be stored in containers more than 100 l within 100 m of a watercourse or a water body. Placing proper containers within the construction camp and permanent work sites in order to collect all kinds of common solid waste such as: glass, paper, cardboard and plastic waste and packaging. Common waste will be transferred to the containers of the company responsible for general domestic waste collection or by the contractor towards a dumping site which is formally used for domestic waste. Hazardous waste such as batteries, oil filters, etc., shall be collected in special containers proof for any leakage/spillage. If not recycled, they will be conveyed to adequate landfill.	All worksites and construction camps	Construction	Contractor	SEC/IEO + ESC	Non compliance statement in works monthly report	No marginal cost

SEC: Senior Environmental Consultant – IEO: Internal Environmental Officer (HUEWACO) – ESC: Environmental Supervision Correspondent (supervision team)

Table 9.2: Mitigation Plan of impacts potentially occurring in construction phase (continuing)

Impact	Activity	Mitigation measure	Locations	Period	Responsible for Implementation	Responsible for Supervision	Means of Verification	Cost
Destruction of terrestrial flora and fauna	Site cleaning / preparation	Manual land clearing. Cutting trees above 4 m high or with aesthetic value shall request authorization of the Supervisor. In residential or suburban areas: - temporary fences placed around the roadside or adornment trees not to be felled - replantation of felled roadside or adornment trees in the same site but in such a way that the roots of the new tree will not likely to damage the buried pipe.	All work sites	Construction	Contractor	SEC/IEO + ESC		No marginal cost
		Tree plantation on 200 ha, Involvement of Forestry Service in choice of species, plantation methodology. Plantations will be made by local communities through skilled NGOs and under the supervision of Forestry Department.	Public/community area (e.g. buffer zone of a protected area).	Construction	Skilled NGO and local communities	Forestry Service		
		The detailed design of the water intake of the Loc Tri DWT and the raw water pipe shall be submitted and approved by the management board of Bach Ma NP.	Loc Tri intake, raw water pipe and WTP	Pre-construction	Contractor	SEC/IEO + ESC		No marginal cost
Damage to private and public goods	Site cleaning / preparation Earthworks Pipe laying	Detailed location private and public goods likely to be affected by works and working with care in the vicinity of these goods. In case of damage, full restoration by the contractor at its own expenses	All work sites, more particularly where laying water pipes	Construction	Contractor	SEC/IEO + ESC	Non compliance statement in works monthly report	No marginal cost
Disruption to public services	Site cleaning / preparation Earthworks Pipe laying	Detailed location of public services. Continuous liaison with operating companies/authorities in order to properly protect and/or divert public services without heavy impacts. In case of anticipated cut-off, information of the served population to attenuate disturbance. When working in the vicinity of overhead power cables, the contractor shall ascertain and satisfy himself about the safe clearances to be maintained from the power cables in consultation with the authority operating the power line. Contractor's full responsibility for any damage and for full restoration of the damage.	All work sites, more particularly where laying water pipes	Construction	Contractor	SEC/IEO + ESC		No marginal cost

SEC: Senior Environmental Consultant – IEO: Internal Environmental Officer (HUEWACO) – ESC: Environmental Supervision Correspondent (supervision team)

Table 9.1c: Mitigation Plan of impacts potentially occurring in construction phase (final)

Impact	Activity	Mitigation measure	Locations	Period	Responsible for Implementation	Responsible for Supervision	Means of Verification	Cost
Disruption to road traffic	Site cleaning / preparation Earthworks Pipe laying	The contractor shall ensure the continuity of the road traffic. If traffic interruption is necessary, the information of the concerned population shall be ascertained by the contractor with a proper schedule in order to attenuate disturbance. After laying pipe and backfilling the trench with adequate material, all the damaged surface of carriage ways and sidewalks shall be restored in accordance to the relevant Vietnamese standards,	All work sites, more particularly where laying water pipes	Construction	Contractor	SEC/IEO + ESC		No marginal cost
Increased risk for health and safety of nearby population	Site cleaning / preparation Earthworks Pipe laying	Seed limit for contractor's and subcontractor's vehicles: 40 km/h inside residential areas and 50 km/h outside residential areas. The contractor shall provide a written and clear traffic control plan including schedules and places of flagmen, traffic cones, barricades and/or lights. Work sites on along roads shall be properly signposted with adequate marks and tools such as cones and coloured bands. Fences to protect pedestrian, on diversion paths. Access to private houses, shops and all commercial public buildings shall be preserved by the means of safe footbridges. (See also measures against noise, vibration and air pollution)	All work sites, more particularly where laying water pipes	Construction	Contractor	SEC/IEO + ESC		No marginal cost

SEC: Senior Environmental Consultant – IEO: Internal Environmental Officer (HUEWACO) – ESC: Environmental Supervision Correspondent (supervision team)

Table 9.2: Mitigation Plan of impacts potentially occurring in operation phase

Impact	Activity	Mitigation measure	Locations	Period	Responsible for Implementation	Responsible for Supervision	Means of Verification	Cost
Soil erosion	Laying water pipe in non surface areas	Plantations of autochtonous herbaceous species on the top of the backfilled trench in natural areas (50 ha in total).	Natural areas crossed by pipe network	Construction	Skilled operator	SEC/IEO + ESC	Plantation report	
Decrease of river flow	Water abstraction	Conducting Environmental Flow Assessments (EFA) for new WTPs using raw water from medium and small size rivers, i.e. Loc Bon (Nong River), Loc An (Truoi River) and Loc Tri (Khe Su River).	Loc Bon WTP Loc An WTP Loc Tri WTP	Pre-construction	Consulting company	SEC/IEO + ESC	Study report	
Pollution of river by discharging sludge	Water treatment	Installing drying beds in the WTP of more than 10,000 m^3/d i.e. Phong Tu WTP (210 m^2), Tu Ha WTP (120 m^2), Loc Bon WTP (300 m^2) and Loc An WTP (120 m^2).	Phong Tu WTP Tu Ha WTP Loc An WTP	Construction	HUEWACO	HUEWACO	Supervision report	
		Study on possible outlets for drinking water treatment sludge within the TTH Province.	TTH Province	Pre-construction	Consulting company	HUEWACO	Study report	
Adverse effect on landscape and sceneries	WTP and booster station buildings	Landscaping works in Phong Tu WTP, Tu Ha WTP, Loc Bon WTP, Loc Anh WTP and Loc Tri WTP as well as the seven new booster stations.	Phong Tu WTP Tu Ha WTP Loc Bon WTP Loc Anh WTP Loc Tri WTP 7 new booster stations.	Construction	Skilled operator	SEC/IEO + ESC	Supervision report	

SEC: Senior Environmental Consultant – IEO: Internal Environmental Officer (HUEWACO) – ESC: Environmental Supervision Correspondent (supervision team)

9.3. MONITORING PLAN

Monitoring will address parameters associated with the main potential impacts of the Project on the environment during the construction, but mostly the operation phase. During the construction phase, the main part of the monitoring activities focus on the contractor's environmental practices aiming at reducing, preventing or restoring environmental damages, hence monitoring can be compared to an "environmental supervision". During the operation phase, the monitoring aims to characterize the source of damage to environment (for example, air pollutant emissions) and the consequent change of receiving environment.

The environmental supervision will be carried out by the Environmental Team of the PMU (SEC and/or IEO) together with the Environmental Supervision Correspondent of each contracted work (ESC) mentioned above. The supervision should be mainly based on

- frequent visits of work sites, work camp and facilities
- discussion with the Contractor's staff, especially the Site Environment, Health and Safety Officer (SEHSO)
- discussion with the nearby population and other stakeholders
- monitoring of supervision indicators, some of which being actually non observance of environmental requirement by the contractor rather than classical quantitative indicators

Actually, it is difficult to propose only quantitative indicators for supervision, except for additional environmental works (for example, tree plantations) which should be monitored as the other (core) works, because environmental practices are a set of behaviours the assessment of which is subjective. The qualitative indicators set out in Monitoring Plan (will be considered as items of check-list and the SEC/EIO/ESC will have to review and comment each item and to establish, if the need arises, a non-compliance note to be slot in the monthly supervision reports.

The (quantitative) indicators to be monitored during the operation phase will be relating to:

- the sources of impacts: level of river water downstream of WTP, quality of effluent and sludge
- the quality of receiving physical environment: raw water and sediment downstream of WTP discharge point
- public health indicators (waterborne disease)
- the quality of the resource i.e. the raw water, in particular for those parameters which are not monitored by HUEWACO such as pesticides (10 insecticides and 3 herbicides according to standard TCVN 5942:1995). A biannual sampling (high water and low water periods) will be carried out and sent to a specialized laboratory for such analyses.

It is clear that HUEWACO shall keep on monthly quality monitoring of both raw and treated waters of the totality of the operated WTP, including those which are remote and/or of small dimension.

Overall monitoring activities are described Table 9.3 and 9.4.

Table 9.3: Monitoring Plan for the construction phase

Environmental impacts	What?	When?	Where?	How?	By Whom?	Cost (US Dollar)
Air pollution	Overall assessment based of site visit Spreading of water/wetting agent is residential area Use of tarps on the hauling trucks	Continuously during construction phase	Every work sites	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
	Compliance with standard for Total suspended Particles (TCVN 5937:2005)	Monthly during construction phase, 10 sites on average	Work sites in residential areas	As per standard	Skilled operator	
Noise and vibration level	Overall assessment based of site visits Control of working hours	Continuously during construction phase	Every work sites	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
	Compliance with standard for noise and vibration levels (TCVN 5949:1998 and TCVN 6962:2001)	Monthly during construction phase, 10 sites on average	Work sites in residential areas	As per standard	Skilled operator	
Soil and water pollution	Fuel storage Imperviousness of fuel and maintenance areas Restriction to on-site fuelling Waste oil collection and storage Collection and elimination of domestic solid waste Collection and elimination of hazardous waste Spillage of oil and other harmful substances (*) Disposal of spoil material and other solids Compliance/approval of stockpiling area	Continuously during construction phase	Every work sites	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
Damage to terrestrial flora	Number of trees protected with fences Number of felled trees (*) Justification of felling Surface planted with herbaceous species (pipe routes) (*) Surface of forest re-plantation (*)	Continuously during construction phase	Every work sites	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
	Approval of detail design for water intake and raw water pipe by Bach Ma NP management	Preconstruction phase	Loc tri WTP	Approval decision from BMNP management	SEC + IEO	No marginal cost
Protection of public and private utilities	Number of incidents (*) Complaint from the owners and affected populations (*) Damage left without satisfying restoration	Continuously during construction phase	Every work sites	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
Disruption to public services	Number of incidents (*)	Continuously during construction phase	Every work sites	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
Traffic management	Frequency/number of traffic jams (*) Number of traffic disruptions (*)	Continuously during construction phase	Every work sites	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
Safety of nearby population	Speed limitation Relevant road signs Number of incidents/accidents (*)	Continuously during construction phase	Work sites in residential areas	Visual control, reporting in the work monthly report	SEC + IEO + ESC	No marginal cost
All kinds of impacts affecting the population	Complaints from riparian population, see grievance redress mechanisms (*)	Continuously during construction phase	Work sites in residential areas	Registration of complaints	Grievance redress office of HUEWACO	No marginal cost

(*) quantitative indicators
SEC: Senior Environmental Consultant – IEO: Internal Environmental Officer (HUEWACO) – ESC: Environmental Supervision Correspondent (supervision team)

Table 9.4: Monitoring Plan for the operation phase

Environmental Impact	What?	When?	Where?	How?	By Whom?	Cost (US Dollar)
Abstracted raw water quality	Pesticides in raw water	Yearly (low water period)	All WTP: upstream of intake	Sampling and analysing with suitable equipment (standardized method)	External specialized laboratory	5,005
River Pollution	Analyses of treatment sludge: - on the liquid (fresh) sludge: pH, suspended solids, TDS, COD, BOD - after drying: total analyses: Al, As, Cd, Co, Cu, Cr, Fe, Hg, Mn, Ni, Pb, Zn (in mg/kg dry solids)	Quarterly (high water, low water and 2 interim sampling)	At all WTP using PAC: treatment sludge before discharge or upstream of drying beds	Sampling (tree samples analysed separately), treatment and analyses with suitable equipment (standardized method)	HUEWACO (Quang Te laboratory) and external accredited laboratory	
	Analyses of effluents (drainage water of drying beds): pH, suspended solids, TDS, COD, BOD, Al Al, As, Cd, Co, Cu, Cr, Fe, Hg, Mn, Ni, Pb, Zn	Quarterly	At all WTP equipped with drying beds for sludge	Sampling and analysing with suitable equipment (standardized method)	External accredited laboratory	
Sediment quality	Analyses of sediment total metals and metalloids in mg/kg dry solids: Al, As, Cd, Co, Cu, Cr, Fe, Hg, Mn, Ni, Pb, Zn	Yearly	All WTP: Downstream of discharge points	Sampling of the 0-10cm top layer in low water period: 5 to 10 sample pooled along transect at 2 locations: 10 m and 100m downstream of discharge point (transects should be benchmarked in the river banks)	Skilled operator (sampling and analysis)	
Waterborne disease	Epidemiological data relating to waterborne diseases in the communes impacted by the project: incidence rate of diarrhoea, amoeba and bacterial dysenteries, cholerae (improving situation expected)	Yearly	From statistical service of Department of Public Health (DOPH)	Collecting detailed data from DOPH and treating them with respect to the improvement of water supply in the communes	SEC/IEO	

SEC: Senior Environmental Consultant – IEO: Internal Environmental Officer (HUEWACO) – ESC: Environmental Supervision Correspondent (supervision team)

9.4. ENVIRONMENTAL COST ASSESSMENT

9.4.1. COST OF ENVIRONMENTAL MEASURES

Tree plantations

Unit cost: US$300 /ha

Total cost: 300 * 200 ha = US$60,000

Plantation of herbaceous species on water pipe routes

Unit cost: US$1,500 /ha

Total cost: 1,500 * 50 ha = US$75,000

Sludge drying beds

Unit cost: US$125/m2 (based on data from management Quang Te WTP)

Required surface of drying beds: 210 m^2 at Phong Tu WT, 120 m^2at Tu Ha WTP, 300 m^2 at Loc Bon WTP and 120 m^2 at Loc An WTP = 750 m^2 in total.

Total cost: 125 * 750 m^2 = US$93,750

Environmental flow assessment

Unit cost (expert): US$2,500 / person-month

Total cost: 2,500* 4 person-months: * 3 sites = US$30,000

Study of potential outlets for drinking water sludge in TTH Province

Unit cost (expert): / person-month

Total cost: 2,500 * 3 person-months = US$7,500

9.4.2. COST OF ENVIRONMENTAL MONITORING

Noise monitoring

Unit cost: US$ 3 / measurement

Total cost: 3 * 10 sites * 12 month = US$360 per year

Vibration monitoring

Unit cost: US$ 3 / measurement

Total cost: 3 * 10 sites * 12 month = US$360 per year

Air monitoring (Total suspended Particles)

Unit cost: US$ 4 / measurement

Total cost: 4 * 10 sites * 12 month = US$480 per year

Pesticides in raw water (13 substances)

Unit cost:

- analysis: US$ 35 / substances
- sampling: supported by HUEWACO

Total cost: 35 * 13 subs. * (10 rivers + 1 groundwater) = US$5,005 per year

Sludge analysis (liquid raw sludge)

Performed and borne by HUEWACO (routine monitoring of basic parameters)

Sludge analysis (dry solids)

Unit cost: US$6 / metal & metalloid substances

Total cost: 6 * 12² subs. * 12 WTP * 4/y = US$3,456 per year

Effluent analysis

Basic parameters: analysis performed and borne by HUEWACO (routine monitoring of basic parameters)

Unit cost: US$6 / metal & metalloid substances

Total cost: 6 * 12 subs. * 4 WTP * 4/y = US$1,152 per year

River sediment analysis ()

Unit cost: US$6 / metal & metalloid substances

Sampling: US$15 /campaign/WTP

Total cost: (6 * 12 subs. * 4 WTP * 4/y) + (15 * 4 WTP * 4/y = US$1,392 per year

9.4.3. COST OF TECHNICAL ASSISTANCE

Expert

Unit cost (expert): US$2,000 / person-month = US$24,000 / person-year

Total cost (expert): 24,000 * 5 person-years = US$120,000

Operating cost

Additional cost: vehicle (4x4): US$ 40,000

Additional cost: computer, stationary, other expenses: US$ 10,000

9.4.4. RECAPITULATION OF ENVIRONMENTAL COST

Environmental cost are recapitulated Table 9.5. Three kinds of cost can be identified:

- lump sum costs for environmental measures implemented once in preconstruction, construction or operation phase
- recurrent costs for monitoring activities to be implemented once or several times every year of the all operation phase (undermined, long period)
- recurrent costs for activities to be implemented during a limited period i.e. technical assistance

If it is assumed that the Project will finance its environmental management during a five year period (duration of technical assistance to EMU), the total environmental budget of the Project will amount to nearly US$500,000.

Table 9.5: Environmental costs in US Dollar

Item	Lump sum cost	Yearly cost	Cost for a 5-year monitoring period
Environmental Measures			
Tree plantation	60,000		60,000
Plantation of herbaceous species	75,000		75,000
Sludge drying beds	93,750		93,750
Environmental flow assessment	30,000		30,000
Study on sludge outlets	7,500		7,500
Subtotal measures	**266,250**		**266,250**
Environmental Monitoring			
Noise		360	18000
Vibration		360	1800
Air (TSP)		480	2400
Pesticides in raw water		5,005	25025
Metals in sludge		3,456	17280
Effluent		1,152	5760
River sediments		1,392	6960
Subtotal monitoring		**12,205**	**61,025**
Technical assistance			
Expert		24,000	120,000
Vehicle	40,000		40,000
Other operating cost	10,000		10,000
Subtotal technical assistance			**170,000**
TOTAL			**497,275**

10. FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

The implementation of the Thua Thien Hue Province Water Supply Project will be critical for the improvement of water supply throughout the whole territory of the TTH province and subsequently for health condition among the dwelling population including the most vulnerable.

The specificity of the Project is that it consists of a set of eleven water supply subprojects including at least one of the three following components: (a) construction/extension of a drinking water treatment plant and its ancillary equipment (water intake), (b) construction of booster pumping station and (c) laying of water distribution network (size from 100 to 1200mm diameter). These subprojects are spread out over the all territories of the TTH province and mobilize waters from ten rivers, of which four belong to the same catchment basin (Huong, Bo, Hu Trach. and Khe Tre River).

Public consultation process has been initiated for three sub-project but need to be completed.

One of the subprojects (Loc An) is located in the buffer zone of a protected area (Bach Ma National Park) and another one (Loc Tri) is partly located within the core territory of the same park (water intake and raw water transport pipe), however, no major or not mitigable impact is expected from the implementation of both subprojects.

The main impacts likely to be caused by the Project are:

- damage to soil and vegetation and nuisance to nearby population in the construction phase, especially when laying the water pipe networks. This will be mitigated through environmental requirements for contractors.
- the risk of important depletion of the water level subsequent to the water abstraction for drinking water production. This will be mitigated by the performance of environmental flow assessment.
- the discharge of treatment sludge (aluminum) into the watercourses. This will be mitigated through dry

To ensure that the environmental impacts will be adequately managed it is proposed to recruit a Senior Environment Consultant for 5 years. A usual approach is to totally rely on the supervision team to deal with environmental supervision of the works but in this case, as many subproject or part of subproject are likely to be attributed to different contractors of diverse size, it would be difficult for each of them to mobilize skill environmental supervisors. Accordingly a “central” multi-site supervision has been preferred for this Project. The Senior Environment Consultant will also be in charge of training HUEWACO junior engineers on-the-job and all relevant management staff by lectures.

It is critical to remember that this IEE has considered that the recommendations issued by the water resources specialist (*Water Conservation Issues in Thua Thien Hue Province: Threats and Possible Responses*, April 2009) will be observed by HUEWACO in the short and medium terms; the implementation of the training program for ISO 14001 certification is also supposed to be implemented.

Eventually, the positive effects of the Project will be dramatically enhanced if an adequate program for improving access to drinking water to the population dwelling far away of water supply networks (mountainous areas) and to the boat people. Both aspects have been addressed by ADB consultants in the framework of this Project.