Initial Environmental Examination

Project Number: 41456-033
June 2012

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

ADB PPTA No. 7144-VIE

Da Nang Water Supply Project

INITIAL ENVIRONMENTAL EXAMINATION

(REVISED TO INCLUDE PFR2 INVESTMENTS ONLY)

Revised June 2012

CONTENTS

ABBREVIATIONS

ADB	Asian Development Bank
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
CPC	Commune People's Committee
DACRISS	Da Nang and Central Region Integrated Strategy Study
DARD	Department of Agriculture and Rural Development
DAWACO	Da Nang Water Supply Company
DNPC	Da Nang People's Committee
DONRE	Department of Natural Resources and Environment
DPC	District People's Committee
DPI	Department of Planning and Investment
EIA	Environmental Impact Assessment
GERUCO	Vietnam Rubber Group Company
IEE	Initial Environmental Examination
LCPD	Liters per Capita per Day
LEP	Law on Environment Protection
MARD	Ministry of Agriculture and Rural Development
MASL	meters above mean sea level
MOD	meters over datum
MONRE	Ministry of Natural Resources and Environment
MPN	Maximum Probable Number
NEA	National Environmental Agency
NPV	Net Present Value
NRW	Non-Revenue Water
PAC	Poly-Aluminum Chloride
PMB	Project Management Board
PPC	Provincial People's Committee
PPTA	Project Preparation Technical Assistance
RBO	River Basin Organization
SEA	Strategic Environmental Assessment
TDS	Total Dissolved Solids
TOR	Terms of Reference
TSS	Total Suspended Solids
USP	Utility Support Project
UXO	Unexploded Ordnance
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Background and Scope

1. The project, classified as *Environment Category B*, is judged to have no adverse environmental impacts. The unavoidable construction impacts are temporary and can be mitigated. Under the second tranche (PFR2) of the multitranche financing facility (MFF), Water Sector Investment Program (MFF0054-VIE), the environmental assessment covered only the investment for the distribution network for the treated water. **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 Da Nang water supply to be implemented over 10 years.**

2. Under a subsequent tranche, Da Nang will have to invest in water production. While a review of the water resources in Da Nang is ongoing, the potential raw water source specified by the Da Nang People's Committee for future production is based on an existing and government-approved plan to build a dam on a tributary of the Cu De River to generate electricity, and subsequently expanded to include water supply. The dam itself is not considered an Associated Facility of the proposed water supply project because the dam's viability and existence do not depend exclusively on providing raw water for Da Nang. Those investments will be reviewed and appraised for financing in a subsequent tranche.

Project Description

3. Water demand in Da Nang is projected to reach 255,000 m^3/day by 2015, and around 500,000 m^3/day by 2025. Existing water treatment facilities only have a total production capacity of 205,000 m^3/day. The existing main raw water source is the Cau Do River, with a water treatment plant (WTP) located on its bank near the city center. When the river salinity is high, raw water is pumped from the An Trach barrage (9 km upstream of the Cau Do WTP).

4. Most of the water flow to the Cau Do River comes from the Vu Gia River which is under a separate jurisdiction (Quang Nam Province) and is subject to strong competition from other water uses. *Under a subsequent tranche, the DNPC has decided to develop an alternative source, the Cu De River, which flows entirely within the city's jurisdiction.*

5. *The proposed overall project, to be financed over several tranches of the MFF0054-VIE, consists of: (a) raw water abstraction from the planned Bac River hydroelectric dam and reservoir located in an upstream catchment of the Cu De River (northwest of Da Nang); (b) conveyance by gravity of the raw water through a 1.4 m diameter pipeline from the reservoir to the treatment plant, spanning a total length of about 16 km; (c) construction of a new water treatment plant at Hoa Lien with a future production capacity of 240 m^3/day to be developed in two stages; and (d) expansion of the water distribution network.* Only item (d) expansion of the water distribution network will be financed under the second tranche PFR2 of the MFF0054-VIE.

6. The new water source is based on an earlier-approved plan to construct a dam on one of upstream tributaries of the Cu De River. The dam's purpose was subsequently expanded to include water supply, following an agreement reached between the DNPC and the dam developer (GERUCO).

7. The reservoir will provide sufficient pressure head to transmit the raw water to the treatment plant thereby reducing operating cost. Drawing water from the reservoir also offers advantages in that it would provide water requiring minimal treatment, as there is little upstream agriculture and habitation in the reservoir catchment which could impair water quality.

8. The raw water pipeline from the dam to the treatment plant will be 15.92 km long. For easier access to construction and future maintenance, the most practical route selected is alongside the existing road.

9. The proposed WTP site at Hoa Lien for financing under a future tranche is situated at the foot of a hill surrounded by paddy fields. The development plan envisions a two-phased development, with each phase producing 120,000 m^3/day. For economy reasons, the initial development of the site would already include common ancillary facilities for both phases.

10. The water treatment process will basically involve two-stages: (1) clarification, and (2) filtration and disinfection. Aside from the conventional water treatment units (receiving tank, reaction tank, settlement tank, filter tank, and clean water tank), other structures to be built at the WTP site are a chemical house, chlorine house, generator house, warehouse, pumping station, and administration office. Chemicals to be used on a regular basis during operation are poly-aluminum chloride (PAC) for flocculation, soda for pH control, and chlorine for disinfection.

11. Water distribution works will entail *construction of a water transmission pipeline and branch pipelines from the Cu De treatment plant to the new and expansion service areas (under future tranches),* including construction of distribution pipes in the served areas (under PFR2). The lay-out of the supply network conforms to the general plan for the development of Da Nang projected up to 2025. Transmission and main pipelines will be built under the roadbed. Smaller branch pipelines will generally be built under the pavement. *Pipeline crossings at the two main rivers (Han River and Cam Le River) will be through existing or planned new bridges, or with the pipe supported by its own bridge structure.*

Impacts and Mitigation Measures

12. The main benefit of the proposed project is decreased supply costs to consumers as a result of shifting from non-piped sources (i.e., shallow wells in the case of Da Nang) to a piped water system under DAWACO. According to the PPTA economic analysis, project would generate direct user benefits valued at $54 M (NPV at 2010 prices). Indirect user benefits include: (a) cost savings of $11.8 M due to shifting from well water to DAWACO water for existing customers (non-incremental water); (b) value of the incremental water supplied, $6.4 M; and (c) value of *health* benefits, $40 M. The EIRR is 15.6%.

13. The Table below summarizes the potentially adverse environmental impacts of the project, mainly associated with construction works, and corresponding safeguards and mitigation measures.

Potentially Significant Impacts of the Project	Summary of Mitigation Measures and Safeguards	Verification and Monitoring Means
Construction: Excavation work for the pipeline trenches will produce spoil; heaps of excavated soil beside the	Temporary heaps of excavated soil to be used to backfill the pipeline trench should not be left on the roadside for long periods, and should be watered regularly	Water quality along the Cu De River (at three locations) adjoining the 16 km pipeline route to be monitored every 3

Potentially Significant Impacts of the Project	Summary of Mitigation Measures and Safeguards	Verification and Monitoring Means
trench could obstruct community access, and erosion from spoil storage areas could silt up nearby streams and drains. Dry heaps could cause dust nuisance.	to prevent excessive dust. At excavation sites close to drains pr streams, silt traps should be used to prevent excessive water turbidity. Storage or disposal areas for excess spoil should be sited so as not to be susceptible to flooding, and not located on steep slopes. Adequate drains/ditches should be installed around the area. Tender documents for construction should require provisions for proper handling and disposal of spoil. Soundness of measures should be part of selection criteria for contract awards.	months throughout the duration of pipeline construction. Include 16 criteria parameters under National technical standard QCVN 08:2008/BTNMT for surface waters. Groundwater quality to be monitored in three locations 2 times per year during project construction: 26 parameters based on Vietnamese Standard QCVN 09:2008 for underground water. Bidding documents, contractor plans and compliance reports on the temporary storage and disposal of spoils. Also, criteria used by the PMB procurement committee in contractor selection. Follow-up consultations and interviews with local residents, every 3 months during construction. (To be done after results of water and air sampling are completed.)
Construction: Obstruction to traffic flow during raw water pipeline construction, exacerbated by the narrow road and work spaces: • *Local residents could be cut off from the road due to the trench-building* • *Increased traffic of dump trucks carrying spoils to and from storage areas* • *Air pollution from excavation and transport equipment* • *Traffic hazard to pedestrians, especially school children and elderly*	*Excavation and transport equipment should be appropriately sized to fit the narrow road and limited work spaces. Impose speed limits.* *Durable wooden or steel plates/planks should be placed across open trenches and drainage ditches to provide temporary crossings.* *Check emissions from construction and transport equipment for compliance with standards, particularly for particulates.* *During dry weather, the construction transport route near residential areas should be sprayed with water to prevent excessive dust. Dump trucks loaded with dry earth should be covered.*	*Air quality to be monitored in 3 locations and every 3 months along the pipeline construction route during construction; include 7 parameters based on Vietnamese Standard TCVN 5937:2005 for air quality.* *Bidding documents, contractor plans, and regulatory compliance reports.* *Criteria used by the PMB procurement committee in contractor selection.* *Follow-up consultations and interviews with local residents, every 3 months during construction.*
Construction: Nuisance and public safety hazards caused by pipeline excavation and pipe-laying activities in urban areas	Work schedules should be well-planned and activities during rush hours near schools and markets should be minimized; construction and materials storage sites should be adequately lighted at night; open trenches must be fenced and clearly marked; and adequate sanitation facilities for workers should be provided at the major work sites.	Bidding documents, contractor plans, and regulatory compliance reports. Criteria used by the PMB procurement committee in contractor selection. Follow-up consultations and interviews with local residents, every 3 months during

Potentially Significant Impacts of the Project	Summary of Mitigation Measures and Safeguards	Verification and Monitoring Means
	Contractors must avoid activities producing loud noise and vibration if night time construction work is necessary. Ensure compliance with existing Vietnamese regulations and standards for managing pollution, nuisance effects, and public safety hazards related to construction works. Tender documents to require contractor to specify safeguards and compliance measures, which will be considered in awarding contracts.	construction.
Construction: Accidental detonation of unexploded ordnance (UXO) during pipeline excavations	*Ensure that the 16 km pipeline excavation corridor is surveyed for unexploded ordnance prior to construction work.*	*PMB will supervise the UXO survey and, if ordnance is detected, will be responsible for commissioning subsequent clearing work prior to construction.*
Operation: Hazard posed by water treatment process chemicals during operation, of which Chlorine is the most hazardous	*Clearly mark the chlorine storage house, storage containers, and associated process equipment, and keep Chlorine containers moisture-free and stored separately from other chemicals.* *Provide adequate personal protective equipment for workers handling chlorine. They should be trained on safe work practices and emergency steps in case of exposure. Adopt regular inspection and maintenance schedule for all chlorine storage and handling equipment.*	*Detailed design of the water treatment plant facilities, and operating rules for the handling of chemicals during commissioning and WTP operation.*
Operation: Disposal of water treatment sludge and wastes from WTP operation	*The recommended design feature of the WTP is dewatering of sludge by plate pressing (producing caked sludge) so that it can be easily transported and disposed in controlled landfill.* *Proper procedures (during plant commissioning) for the disposal of test water, water used for disinfecting tanks, and other chemical wastes from the plant start-up and adjustment process will be incorporated into the contract specifications during the testing and commissioning stage of the WTP.*	*Detailed design of the water treatment facilities, construction plan, commissioning plan and report.*
Operation: Increase in the volume of municipal wastewater generated.	*The city government has planned for the simultaneous refurbishment and expansion of its wastewater treatment facilities—including the upgrading of the existing facilities at Phu Loc and Son Tra, and the construction of a new secondary facility in Hoa Xuan. These facilities are being designed to meet WWTP effluent standards for B-class receiving streams.*	*Regular monitoring reports on wastewater treatment effluent with reference to standards set under TCVN 7222:2002 for the operation of municipal WWTPs, and TCVN 188:1996 on discharge standards for urban WWTPs.*

Information Disclosure, Public Consultation, and Grievance Redress

14. With support from the Environmental Protection Research Center of the University of Danang, public information and consultation activities were carried out as part of a baseline survey of local environmental conditions along the pipeline corridor and in the WTP plant site. A 7-person survey team conducted the survey and interviews with local residents between January 15 and March 3, 2010. Fifty five households along the Cu De River, and 45 households near the pipeline route and WTP site, were covered. Eight community leaders were interviewed in greater depth for their views and concerns regarding the potential effects of the project on the community.

15. Residents responding to the survey questionnaire were informed of its purpose and expected benefits, and the nature of construction activities to be undertaken in the area. Overall, there was no opposition raised against the proposed project. However, respondents and focus group discussants raised concerns that were mostly about: (a) traffic congestion during construction, given the narrow width of the road and alleys in the area, especially in Hoa Lien where there are schools and where a public market is located; (b) potential safety hazards due to speeding trucks and unfenced excavation pits, especially to children and the elderly; (c) dust, vehicle exhaust smoke, noise, and soil spilled on the road during transport of pipeline excavation materials; (d) wastes from construction and clogging of drains; and (d) influx of migrant workers and possible undesirable behavior such as gambling and trouble-making.

16. The Table below gives a summary of the perceptions among local residents as to the potential effect of the project on their livelihoods, usual household activities, and living routines.

Activity Affected	Percent of 55 Respondents along the Cu De River			Percent of 45 Respondents near Pipeline Route and WTP site		
	Serious Adverse Effect	Moderate Effect	Low or None	Serious Adverse Effect	Moderate Effect	Low or None
Farming, fishing or forest resource exploitation	0	4	96	7	15	78
Trading and business activities (including aquaculture)	2	4	94	11	18	71
Cooking, drinking and washing	0	0	100	13	20	67
Living habits	0	0	100	18	29	53
Entertainment	0	0	100	0	13	87

17. The three-stage grievance redress mechanism will be established for raising and resolving grievances related to environmental impacts and community dislocation and resettlement. As a guiding principle, grievances related to any aspect of the Project will be handled through negotiation aimed at achieving consensus. Complaints and grievances will pass through the three stages—first through the Commune People's Committee, second through the District People's Committee, and third through the Provincial People's Committee--before such grievances can be elevated to a court of law as a last resort. DAWACO will shoulder all administrative and legal fees that might be incurred in the resolution of such grievances and complaints.

Environmental Management Set-up

18. *Institutional Arrangement*. The project will be implemented under the Da Nang People's Committee as the Executing Agency and the DAWACO as the project implementing agency. A Project Management Board (PMB) has been created to supervise the implementation, on behalf of DAWACO.

19. The PMB will be responsible for fulfilling the environmental requirements of the project, in particular for incorporating the mitigation measures and safeguards identified in this report in the detailed engineering design of the pipeline, WTP and distribution network, as well as in the bid documents and construction contract documents. The PMB will also be responsible for commissioning water and air quality sampling activities, undertaking environment-related investigations that may arise during implementation (in coordination with the DONRE's Environment Protection Center), and responding to environment or nuisance-related complaints from residents or businesses affected by the project works.

20. The Environmental Protection Research Center of the University of Danang will be tapped to provide environmental monitoring support during project construction (using as baseline the environment survey that was conducted as part of this IEE), and to conduct follow-up consultations and interviews with local residents to identify concerns or grievances arising during construction.

21. A sub-group under the PMB would be designated to handle environment and public safety concerns. Its main duties are to:

- Oversee the implementation of the safeguards related to handling of spoils, water quality protection, public nuisance impacts, unexploded ordnance survey, and public safety;
- Coordinate with the DONRE Environment Protection Center on regulatory compliance issues (for water quality in streams affected by construction drainage or erosion from storage areas for excavated soil, noise and vibration from construction sites, sanitation in workers campsite, etc);
- Check that the safeguards are adequately addressed in the bidding documents (instruction to bidders), and in the evaluation criteria for awarding contracts;
- Prepare terms of reference (TOR) for the survey of the pipeline route to detect unexploded ordnance(if present in the pipeline work areas);
- Prepare TOR for the conduct of water and air quality sampling, including follow-up interviews with local residents on issues and concerns arising during project construction;
- Advise the PMB director on environment-related concerns arising during project construction, and recommend corrective measures;
- Disseminate to stakeholders the results of environment quality monitoring and implementation of safeguards, especially among households or small businesses near the construction sites;
- Prepare a quarterly status reports on environment and public safety protection to be submitted (through the PMB director) to the DNPC.

22. Safeguards compliance monitoring during the construction phase—particularly compliance with safeguard measures specified in construction contracts, as recommended in this report--will be incorporated in the duties of the construction supervision company to be engaged by DAWACO (and supervised by the PMB). The compliance inspections and audits will be documented, and findings and recommendations for corrective measures submitted to DAWACO. During the operation phase, DAWACO will be responsible for safeguards and effluent monitoring, and the findings will be reported to the DONRE.

23. The DONRE Environment Protection Center will conduct random environmental monitoring and inspection before, during, and after construction, as well as in the event of emergencies. It will also review the monitoring reports of the EPRC. If abnormalities are found, the DONRE may impose fines and issue a notice of rectification with a specific deadline to the responsible entities. If complaints are formally received from the public through the People's Committee, the DONRE Environmental Protection Center will carry out verification inspections.

24. Within three months after the construction completion or no later than one year, an environmental acceptance monitoring and audit report on the completion of the project components will be prepared by a qualified environmental institute, e.g., Environmental Protection Research Center of the University of Danang. The report will be reviewed and approved by the DONRE and submitted to ADB.

25. The environmental monitoring, including the environmental benefit monitoring, will be incorporated into the project performance management system (PPMS) indicators for the project. Assisted by a local environment specialist, the PMB will be responsible for analyzing and consolidating the data via their management information system. The PPMS will be designed to allow adequate flexibility to adopt remedial actions regarding the project design, schedules, activities, and development impact. At the start of the project, the PMB and consultants will develop comprehensive PPMS procedures for systematically generating the data on inputs and outputs of the project components, and agree on the environmental and related socioeconomic indicators to be used to measure the project impacts. The PMB will refine the PPMS framework, confirm the achievable goals, firm up the monitoring and recording arrangements, and establish the systems and procedures no later than 6 months after the loan takes effect.

26. *Budget*. The monitoring budget covers: (a) follow-up perception surveys and consultations with local residents to be commissioned by the PMB, preferably with the Environmental Protection Research Center of the University of Da Nang which conducted the baseline environment/site survey and facilitated the public consultations for the IEE; (b) surface water, groundwater and air quality monitoring during construction; (c) survey of the pipeline trench route to check that there are no unexploded ordnance that might endanger construction workers; (d) a local environment specialist to provide intermittent support to the PMB (in preparing survey TORs, assessment of water and air quality sampling results, drafting of safeguard provisions to be incorporated in construction tender documents and contracts, preparing reports to the DNPC and DONRE); and (e) cost of orientation-training for PMB staff and community leaders on managing environmental impacts of pipeline construction and related safeguards (to be facilitated by the environment specialist). The total budget is $200,000, to be funded from the loan proceeds.

27. During the operation of the new water treatment plant, water quality monitoring of drinking water taps at various locations in the new or expanded DAWACO service areas will be done routinely by the Environment Protection Agency of the DONRE in compliance with Vietnam regulations and using the agency's own budget.

Conclusion and Recommendation

28. The proposed project will produce significant benefits for the population of Da Nang, specifically by enabling households that are currently not served or only partially served by DAWACO to shift from reliance on wells as a source of water (which has to be boiled or filtered) to more secure and safe piped water source.

29. The potential adverse environmental impacts of the project are the consequence mainly of construction activities, in particular the potential impairment of water and air quality in areas near the pipeline construction corridor, and nuisance and safety hazards posed to nearby households and small businesses. However, these impacts are temporary and can be mitigated.

30. Households that will be affected by construction activities, either because of dislocation or damage to property, will be relocated and/or compensated in accordance with ADB guidelines. These measures are presented in a separate report focused on the project's resettlement and compensation aspects.

31. For purposes of compliance with ADB environmental assessment guidelines, no additional study or full environmental impact assessment is needed to further assess the potential environmental impacts of the project under PFR2. Environmental Categorization of future tranches will be done separately.

INITIAL ENVIRONMENT EXAMINATION: DA NANG WATER SUPPLY PROJECT
(RAW WATER PIPELINE, TREATMENT PLANT AND WATER DISTRIBUTION NETWORK)

I. BACKGROUND

32. This project, classified as Environment Category B, is judged to have some potential adverse environmental impacts, particularly in relation to pipeline construction activities and, to a lesser significance, the disposal of sludge from the water treatment process. The unavoidable construction impacts are temporary and can be mitigated, whereas adverse impacts related to sludge disposal have been avoided by incorporating sludge dewatering in the design of the water treatment facility.

33. This report was prepared with reference to the ADB safeguard Policy Statement of June 2009. It follows the standard outline for environmental assessments: legal and administrative framework; description of the environment; description of the project and its significance; assessment of environmental impacts and mitigation measures, including alternatives considered; public consultation and information disclosure; and environment management plan.

34. The scope of this assessment covers: *(a) transmission by pipeline of raw water to be abstracted from a reservoir, (b) water treatment facilities, and (c)* treated water distribution. *The water source is based on an existing plan to build a dam on a tributary of the Cu De River. Originally intended for power generation, the dam's purpose was expanded to include water supply.*

35. For this IEE, the hydropower dam is considered an existing project. It had already been approved for implementation by the Da Nang People's Committee (DNPC) in 2007 and then subsequently renegotiated with the hydropower company (GERUCO) to also serve as a water supply source for Da Nang. The dam's viability and existence, as such, do not depend exclusively on providing raw water for the proposed water supply project. As such, the dam is not considered an Associated Facility of the project and is not covered in this environmental assessment. In any case, the government's previous approval for construction of the dam was supported by an EIA prepared by the project proponent and cleared by the Da Nang Department of Natural Resources and Environment (DONRE) in accordance with Vietnam's EIA regulations.

II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

36. Vietnam's Law of Water Resources was passed in December 1999. It establishes water as a resource to be managed as an economic good. Water resources boundaries are to be delineated according to hydrological rather than administrative boundaries. For Da Nang, this is significant because the city's present supply source comes from the Vu Gia River system, which lies outside the city's administrative jurisdiction. The law also gave strong institutional focus on creating a national apex body for water resources management, the setting up of river basin organizations, decentralization of management for water resources assets including infrastructure, and greater accountability for water services delivery.

37. The water law also provided for establishment of more effective regulatory institutions, including the use of abstraction licenses, discharge permits and more strengthened safety procedures for infrastructure development and operation. The Law was not only intended to

facilitate shift to more sustainable and economically efficient development of the country's water resources; it was also intended to support achievement of the country's broader imperatives of poverty alleviation, socio-economic development and environmental protection.

38. The Ministry of Agriculture and Rural Development (MARD) was originally responsible for implementing the water law; this responsibility was later transferred to the Ministry of Natural Resources and Environment (MONRE). Subsequently, MONRE was mandated to direct river basin management activities throughout the country. A river basin organization (RBO) for the integrated Vu Gia and Thu Bon River basin was established in 2005, and the next generation of RBOs is being tested with assistance from a pilot and demonstration activity program assisted by ADB.

39. The Vu Gia – Thu Bon river basin organization is based in Quang Nam province and is being coordinated by the province's Department of Natural Resources and Environment. It appears that the interface between Quang Nam province and Da Nang city for the joint management of the basin's water resources still needs to be strengthened—in particular, with regard to the allocation of water from the Vu Gia River (which is the present source of water supply for Da Nang). The RBO management committee is initiating new approaches to keep Da Nang officials informed of the RBO's activities, and to establish a sustained working relationship for managing the Vu Gia River.

40. The Law of Environmental Protection (LEP) was originally passed in 2003 and took effect in January 2004. Decree 175/CP issued in October 2004 provided implementing guidelines for (a) assignment of environmental management responsibilities among ministries, provinces and people's organizations; (b) an environmental impact assessment system; and (c) a regulatory permitting system based on standards. Chapter III of Decree 175/CP contains requirements for the submission of environmental impact assessments by investors and enterprises; the appendices to the Decree also contained detailed provisions prescribing the format and content of EIA reports. In 1998, Circular 490 was issued providing additional guidelines for the preparation and review of EIA reports.

41. In November 2005, the LEP was revised. Decree 80/2006, issued in August 2006, provided detailed implementation guidelines for the amended law, replacing Decree 175/CP. The project-based EIA system was strengthened, and a new environmental management tool was introduced in the form of strategic environmental assessments (SEA) for national, provincial and inter-provincial development plans, policies and programs. Responsibility for conducting SEAs is assigned to the state agency responsible for formulating the strategy or plan. For instance, the MONRE (with technical assistance provided by ADB) undertook a strategic environmental impact assessment of the Quang Nam province's hydropower development plan for the Vu Gia and Thu Bon river basin, which was completed in 2009.

42. Environmental management in Viet Nam is administered on the national level by the MONRE. The environmental arm of MONRE, the National Environmental Agency (NEA), is the body specifically tasked with environmental protection. Aside from MONRE, environment divisions in the various line Ministries are tasked with environmental management functions related to the specific sectors.

43. At the provincial level, the relevant management authorities are the Departments of Natural Resources and Environment (DONRE) which carry out their environmental protection activities through their respective environment divisions. In the case of Da Nang DONRE, an Environment

Protection Center is responsible for monitoring environment quality and providing technical solutions. The DONREs come under the purview of the central MONRE only in relation to administrative matters and technical guidance. For all other purposes, the DONREs operate under the direct control of their respective provincial governments, through the People's Committees.

III. PROJECT DESCRIPTION

44. Water demand in Da Nang is increasing, driven by the city's rapid development and population influx in recent years. The growing metropolis is envisioned to become a key junction of the future Trans-Asia highway that will serve as gateway for international trade, giving strategic sea access for the country's central highlands and the neighbouring countries of Laos, Cambodia and Thailand. The city's current population which is approaching 1 million is expected to grow at a rate of 2.5% annually.

45. Water demand is projected to reach 255,000 m^3/day by 2015; 375,000 m^3/day by 2020; and around 500,000 m^3/day by 2025. Existing water treatment facilities only have a total production capacity of 205,000 m^3/day--170,000 m^3/day from the existing facility at Cau Do which draws water from the Cau Do River; 30,000 m^3/day from a treatment facility located near the airport (which is also supplied by a raw water pipeline from the Cau Do River); and 5,000 m^3/day from spring sources at the Son Tra peninsula.

46. The existing main water supply system of Da Nang takes water from the Cau Do River, with a a water treatment plant located on the banks of the Cau Do River (Figure 1). When the Cau Do river salinity is high, raw water is taken at the An Trach barrage on the Yen River (an upstream tributary of the Cau Do River). From here the water is pumped through an existing 9 km pipeline to the Cau Do water treatment plant.

47. Most of the river water currently supplied to the Cau Do WTP comes through the Yen River from the Vu Gia River. The latter has a very large catchment (5,900 km2) but it is under a separate jurisdiction (Quang Nam Province) and is subject to strong competition from other water uses.

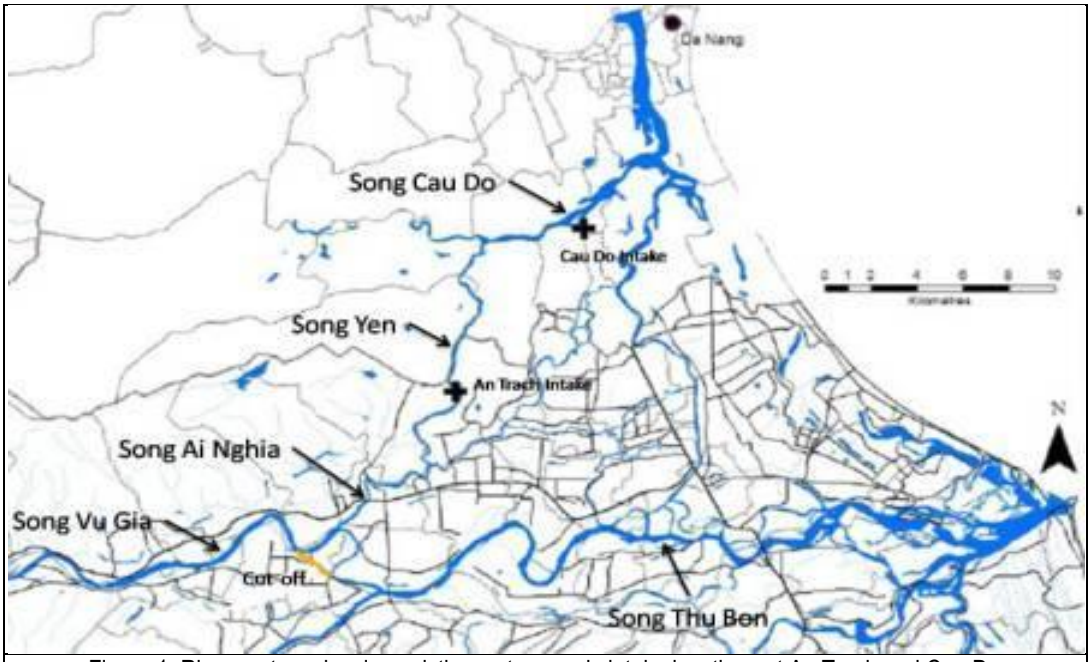


Figure 1. River system showing existing water supply intake locations at An Trach and Cau Do

48. The DNPC has decided in favor of developing the Cu De River as a strategic new water supply source for Da Nang -- in large part because the water catchment lies entirely within the city's jurisdiction, unlike the Vu Gia River which is under a separate provincial jurisdiction and consequently more difficult to control in terms of water allocation and quality protection. The water catchment area is also within the existing Ba Na-Nui Chua nature reserve, and conservation and catchment protection activities there are supportive to water quality protection.

49. The proposed project consists of*: (a) raw water abstraction from the planned Bac River hydroelectric dam and reservoir located in an upstream catchment of the Cu De River (northwest of Da Nang); (b) conveyance by gravity of the raw water through a 1.4 m diameter pipeline from the reservoir to the treatment plant, spanning a total length of about 16 km; (c) construction of a new water treatment plant at Hoa Lien with a future production capacity of 240 m^3/day to be developed in two stages; and (d)* expansion of the water distribution network.[1]

50. The new water source is based on an approved plan to construct a dam at a narrow gorge on the Bac River, one of upstream tributaries of the Cu De River. The dam was originally designed for power generation, and was subsequently identified as a viable water supply source for Da Nang. The operation of the reservoir would increase the 90% reliable flow to about 11 m^3/s, about a third of which is can be allocated for water supply, with the development spread over at least two phases.

51. The reservoir will provide sufficient pressure head to transmit the raw water to the treatment plant thereby reducing operating costs. From the available head of about 45 m to the WTP, the energy that can be recovered at the end of the water supply pipeline can be used to generate electricity to drive the water through pressure filters.

[1] During the project preparation, a component on the refurbishment of a decommissioned 50,000 m^3/day water treatment facility at Cau Do was also assessed. This additional component would help meet near-term water demand while the new water source at Cu De is being developed. However, it is no longer included in the scope of the ADB-funded project, as DAWACO has decided to finance the refurbishment itself.

52. Direct abstraction from the Song Bac reservoir also offers advantages in that it would provide water requiring minimal treatment, due to natural purification processes in the reservoir.[2] There is little upstream agriculture nor habitation in the reservoir catchment which would supply nutrients, so the risk of eutrophication is low. Water samples from the Bac River taken in July 2009 and September 2009 showed good quality. Forty-one out of 42 parameters tested for the July sample had values that were below the limits of the national technical standards for surface water quality.

53. Shown in Figure 2 is the general scheme of the raw water abstraction from the Bac River. The site had been previously planned and approved for hydro-electric power development under GERUCO (a power development company). The purpose of the dam to be built was later on expanded to include water supply, based on an agreement reached between the Da Nang People's Committee and GERUCO. The inflow to the natural catchment area of the dam will be augmented by transferring water through a pipeline from the adjacent Nam River catchment, thereby increasing the volume of water that can be stored in the reservoir. This water transfer scheme, including two other small cascade dams to be constructed inside the main reservoir catchment, are designed to also increase the hydropower output from the area.

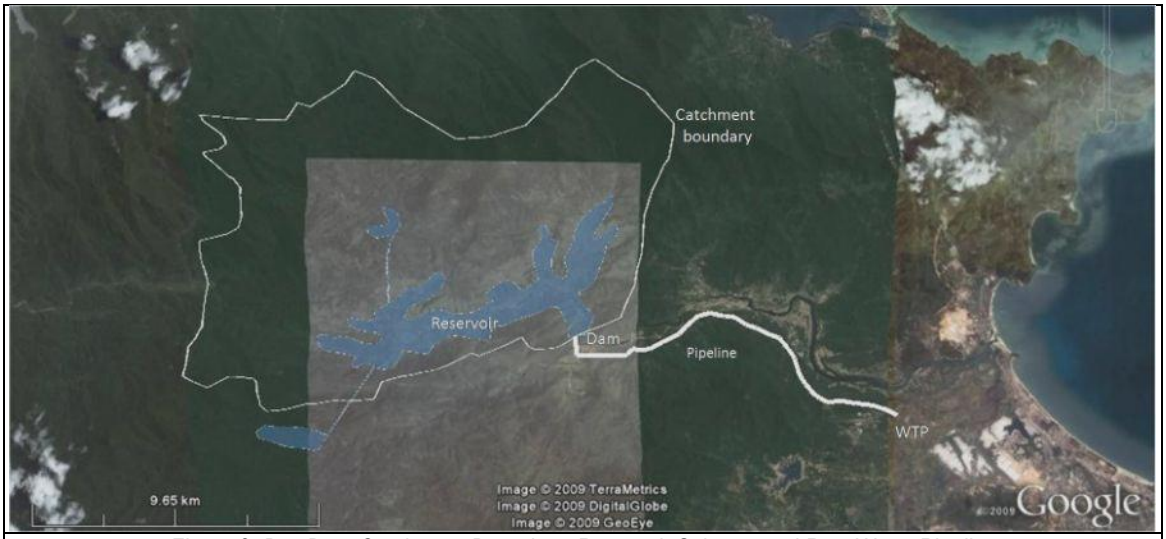


Figure 2. Bac Dam Catchment Boundary, Reservoir Scheme and Raw Water Pipeline

54. The proposed raw water pipeline from the dam to the treatment plant will be 15.92 km long. Based on topographic surveys, the route can be divided into five sections, described in Table 1. For access to construction and future maintenance, the most practical route selected is alongside the existing road.

Table 1. Sections of the Raw Water Transmission Pipeline

Pipeline Section		***Characteristics***
1	*From the dam to the Sap Bridge (630 m) where the pipeline crosses the Nam River*	*The first 400 m section of the pipeline along the river bank downstream of the dam is beside a vertical rugged cliff. Placement of the water pipeline in this section will require cutting into the rock slope, and reinforcing the riverbank to protect against river scouring.*
2	*Pipeline crossing at the Nam*	*A 100 m section of pipeline would cross the rock and gravel bed of*

[2] Reservoirs facilitate control of bacteria through ultra-violet radiation and other natural processes, and sedimentation would remove much of the suspended sediments.

Pipeline Section		Characteristics
	River at the Sap Bridge	*the Nam River, proposed to be constructed as an inverted siphon. Because of the turbulent flow in the area during floods, the buried pipeline needs to be reinforced.*
3	*From the Nam River crossing to Na My*	*This 4.4 km section will follow the alignment of the provincial road (601) which is 3-4 m wide and crosses undulating terrain. The south side of the pipeline route faces steep hillsides. The north side faces the Cu De River, and many parts of the riverbank in this section have steep side slopes. Habitation is not dense, and there is an existing resettlement area for people affected by downstream flooding that will be traversed by the pipeline.*
4	*From Na My to the bridge at Nam Hai Van*	*This 10.4 km section of the pipeline also follows the provincial road alignment. The south side of the pipeline route is bordered by hills which are steep in some portions. The north side is bordered by the meandering Cu De River. Land use in this section is a mix of human settlements and farms.*
5	*From the bridge at Nam Hai Van to the WTP site at Hoa Lien*	*This 420 m final section of the pipeline follows the provincial road alignment, and the section is surrounded by dense housing and some ongoing construction activities.*

55. Highway 601 provides the only road access to the inhabitants of the Cu De Valley, so during construction it cannot be closed off. The existing road is very narrow, making the option of placing the pipeline under the road infeasible--as it would cut off traffic and be extremely disruptive to the local community—except in certain areas where the valley side is almost vertical and there is no other space available for the pipeline trench. With these as considerations, Table 2 shows the proposed construction solutions for the pipeline in accordance with the topographic characteristics of each section.

Table 2. Proposed Pipeline Construction Solutions

Section	Construction Methods
1	*Construct new 9m wide access road including 3m wide shoulder for pipeline on inside of hill slope. Slope protection will be required. At gulleys and unstable sections, the pipeline would be laid in a concrete casement or reinforced concrete culvert to provide protection. Pipeline cover to be 1m minimum depth.*
2	*Excavate trench in rock bed of river, and lay steel pipeline encased in steel-reinforced concrete.*
3, 4, 5	*Excavate an additional 4 m wide shoulder on the right side of the road (to provide sufficient space for road drainage). Lay pipeline in a trench and provide 1.2m cover.* *Appropriate construction solutions must be designed for steep sections, unstable side slopes and gully crossings. Where necessary the pipeline should be laid with concrete surround or with in-situ or precast reinforced concrete cover slab.* *Where the pipeline crosses side streams, either construct an inverted siphon placing the pipeline in a trench filled with concrete or construct a pipe bridge with reinforced concrete pillars to carry pipeline across the stream above 25 year design flood level.*

56. For the (inverted) siphon crossing at the Nam River, the steel pipes will be placed in a trench with a concrete culvert. Where the river bed is close to rock foundation, the trench will be excavated in the bed rock itself and then backfilled with concrete. The riverbed at the crossing section is made up of gravel and boulder. The pipe sections will be connected to each other and to valves and pipe fittings by flanges and bolts.

57. As for the WTP site at Hao Lien, the site was identified several years ago and has been approved by DNPC. It is located at the lower end of the Cu De valley where the river valley meets the coastal plains in the north western part of the city, and lies at the foot of a hill surrounded by mostly paddy fields lies (Figure 3). The area north-west of the site where the pipeline will enter the treatment plant is occupied by houses and other small structures. There is a low hill inside the lot, and another part is filled in with disposed excavated material.

58. The basic plan for the treatment plant envisions a phased development, with an initial phase targeting treated water production of 120,000 m^3/day and a second phase targeting an additional 120,000 m^3/d at a later date. However, for economy reasons, the initial development of the WTP site would already include the common ancillary structures and facilities for both phases, as in the case of the raw water pipeline capacity.

Figure 3. Site and Lay-out of Water Treatment Plant at Hoa Lien

59. The approach to the WTP site development is to set the main facility units as high as feasible in relation to the existing ground level. Such layout would minimize cost of pumping the treated water to the distribution system. The initial construction of a 120,000 m3/day plant will be configured to fit on the hill platform at an elevation above 10 m (above datum). This platform will serve as the base of the WTP clarifier and filter structures. This set-up would also help ensure that the main facilities are not vulnerable to flooding. Figure 4 shows the WTP's general lay-out.

60. The lowest part of the WTP site (south portion) is currently used as a paddy field and is susceptible to flooding. This area will need to be filled and could use the spoils excavated from the pipeline trench. As it is suspected that there could be a considerable depth of soft material beneath the paddy fields, the main structures in this area will be piled. The whole area itself may need soil improvement measures to reduce possible long-term ground settlement.

61. The water treatment process will basically involve two-stages: (1) clarification, and (2) filtration and disinfection. It is proposed to use tube settlers for the clarification stage, as used in the existing facilities at Cau Do. Following clarification, the plan is to use conventional rapid gravity filters for the second stage using sand media (1 m deep) and equipped with conventional air-water washing.

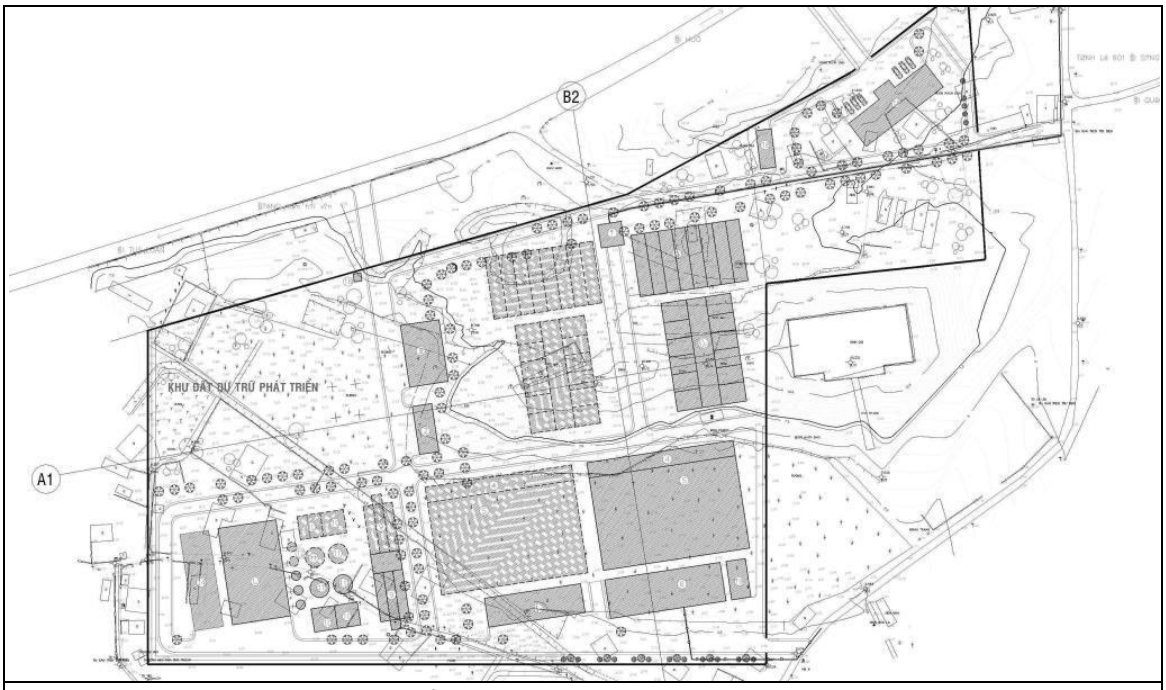


Figure 4. Plan View of the Proposed Water Treatment Plant at Hoa Lien

62. Aside from the conventional treatment units (receiving tank, reaction tank, settlement tank, filter tank, and clean water tank), other structures to be built at the WTP site are a chemical house, chlorine house, generator house, warehouse, pumping station, and administration office. Chemicals to be used on a regular basis during operation are poly-aluminum chloride (PAC) for flocculation, soda for pH control, and chlorine for disinfection. The main components of the WTP are summarized in Table 3.

Table 3. Hoa Lien Water Treatment Plant Components

Main Components	***Design Features***
Receiving Tank, Mixing and Flow Distribution Tanks	*These will be built in a block structure and will be designed for both phases, with 240,000 m^3/day capacity. The receiving tank will be positioned in front of the two mixing tanks. Mixing will be hydraulic for energy efficiency. The flow distribution tank will be positioned behind the mixing tanks.*
Flocculation Tanks	*Only the first block with a capacity of 120,000 m^3/day will be constructed in Phase I. The mechanical flocculators, equipped with variable speed agitators, will be used to reduce tank capacity and provide efficient and adjustable flocculation after chemical dosing. The reaction tank will be built in a block arrangement in line with the settlement tank.*
Settlement Tank	*This tank will also be designed as two separate blocks, each with capacity of 120,000 m^3/day--but only the first block will be constructed in Phase I. The tanks will be designed with tube settlers which provide effective floc settlement and enables the construction area to be reduced. The settlement tank will be built in a block arrangement together with the reaction tank. The settled water is then removed through collection*

Main Components	*Design Features*
	channels. Multiple cone shaped hoppers will collect the sludge at the bottom of the settlement tanks, and the sludge is then conveyed by hydrostatic pressure to the sludge drainage pipes.
Rapid Filter Tank	*A single layer of filter material will be used, using quartz sand or anthracite. The tank will be backwashed by combined water and air pressure through nozzles embedded in the filter floor. Backwash water will be collected from each tank by a main channel. The operation of the filter process will be semi-automatic.*
Contact and Clean Water Storage Tank	*The chlorine contact and clean water storage tanks will be designed with capacity of 120,000 m^3/day for the first stage only. The contact tank will be built at the inlet end of the clear water storage tank. Baffles will be constructed inside the tank to avoid short-circuiting flows. The effective contact time will be designed for 30 minutes.*
Clear Water Pump Station	*The pump station will be designed with sufficient space to accommodate all of the pumps needed for both phases, but only the Phase I pumps will be provided during Phase 1. Control of the pump station can be set to either automatic mode or semi-automatic mode.*
Chemical House	*The chemical house is for storing, preparing and supplying the chemical solutions required for the water treatment process. The structure will provide for storing bagged chemicals (as delivered), the PAC solution for the flocculation process, and lime for adjusting the pH in the water.*
Chlorine House	*The chlorine house is for the production and supply of chlorine solution for disinfection and will be designed to accommodate all of the processes and equipment for both phases. The structure will be designed to store and handle chlorine containers and to house the chlorine supply equipment. The design will incorporate safety features to mitigate the effects of any leakage of chlorine gas. Initially the number of chlorine containers and other facilities provided will only be for the first phase.*
Sludge Balancing Tanks and Thickeners	*Sludge drawn of from the clarifiers would flow by gravity to the sludge balancing tanks and be fed to sludge thickeners. The thickened sludge will be collected from the draw-off pit. A polyelectrolyte will be used to aid sludge thickening (to about 3% w/v). The thickened sludge will then be pumped to holding tanks for dewatering.*
Sludge Press House	*The thickened sludge is dewatered by a filtration process. The feasibility study proposal is to use membrane presses which produce a "cake" that is suitable for disposal to a controlled landfill. The filtrate will be recycled to the sludge holding tanks or thickener inlet so that there is no liquid discharge associated with the sludge dewatering from the treatment works.*

63. *Treated water distribution works will entail construction of a water transmission pipeline and branch pipelines from the Cu De treatment plant to the new and expansion service areas, including construction of distribution pipes in the served areas.* The lay-out of the supply network conforms to the general plan for the development of Da Nang projected up to 2025. The network has been designed in accordance with the projected land use in the city's master plan, and the projected water demand of each sub-area or zone. The lay-out of the water supply pipelines is arranged along the main road network in accordance with the city's spatial master plan. As much as possible, the existing pipelines will be retained and incorporated in the new network.

64. Transmission and main pipelines for water distribution will be built under the road bed, or under the pavement if the width of the pavement is adequate. Smaller branch pipelines will

generally be built under the pavement, unless space is limited, in which case these pipes will be placed under the roadbed. Distribution and service pipes (less than 150 mm in diameter) will be placed under the pavement.

65. Pipeline crossings at the two main rivers (Han River and Cam Le River) will be through existing or planned new bridges, or with the pipe supported by its own bridge structure. The options will be examined during the detailed design phase.

66. The distribution system is planned synchronously as a single network combining the outputs from all of the WTPs in the city and integrating the existing network with the new network expansions in accordance with the total planned capacity of the system up to year 2025. High capacity transfer pipelines will be provided to link the two large-capacity WTPs at (existing) Cau Do and (new) Hoa Lien, so that they can supplement each other when either has a problem. High capacity transfer pipelines will form the spine of the network and will be provided in closed loops to transfer water efficiently to all of the main supply areas of the city including those areas where new urban development is planned. The lay-out of the main pipelines is shown in Figure 5.

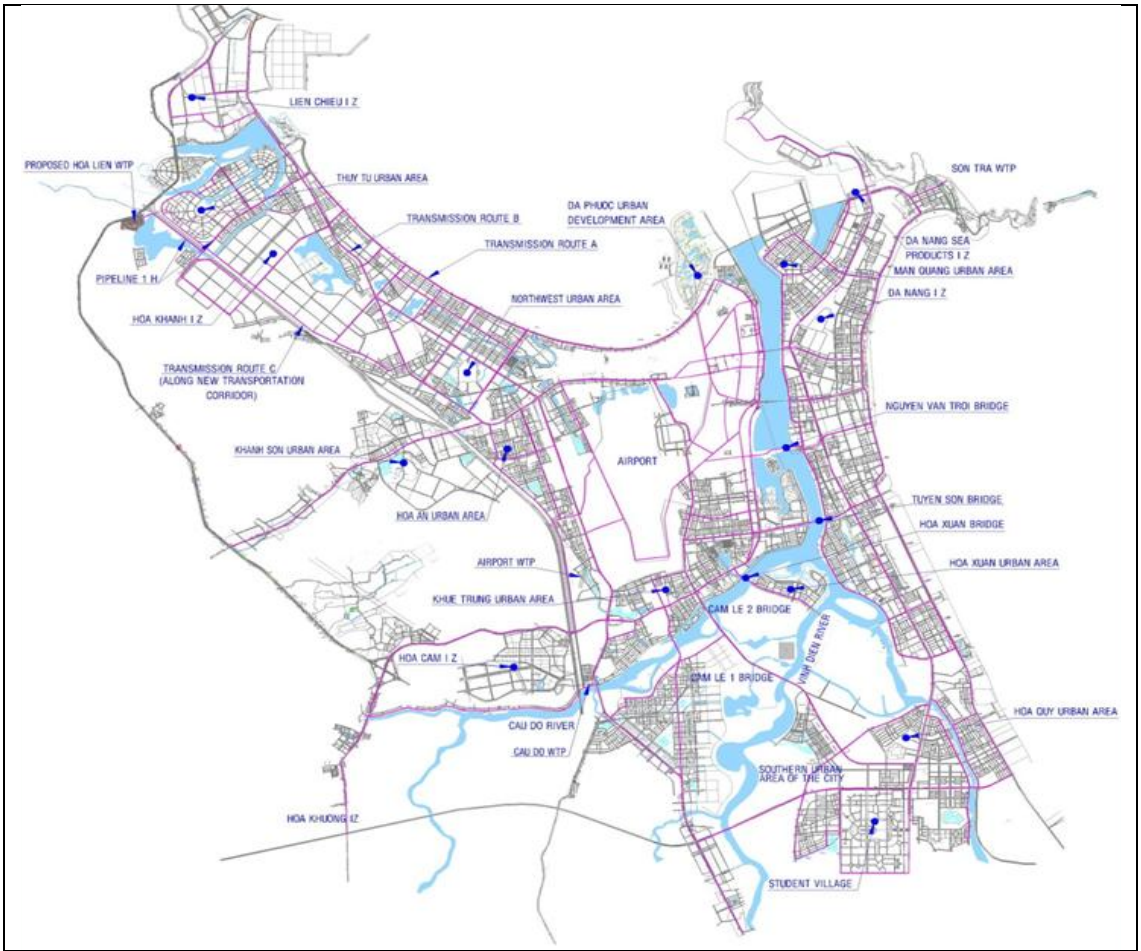


Figure 5. Lay-out of the Water Distribution Network

67. The overall project implementation timetable is shown in Annex 1.

IV. DESCRIPTION OF THE ENVIRONMENT

A. Location, Climate and Geography

68. Da Nang is Vietnam's fourth largest city and one of the country's most important seaports (Figure 6). It is strategically located at the coast and at the center of the country's north-south transportation (highway and railway) axis. The city lies on a coastal alluvial plain surrounded by the Bach Ma Mountain and the Hai Van Pass in the north, the Truong Son Mountain range in the west, and the South China Sea in the east. The city is divided into six urban districts (Hai Chau, Than Khe, Son Tra, Ngu Hanh Son, Lien Chien and Cam Le), and two rural districts (Hoa Vang and Hoang Sa). The urban districts have a total area of 244 sq km, and the rural districts cover 1,009 sq km.

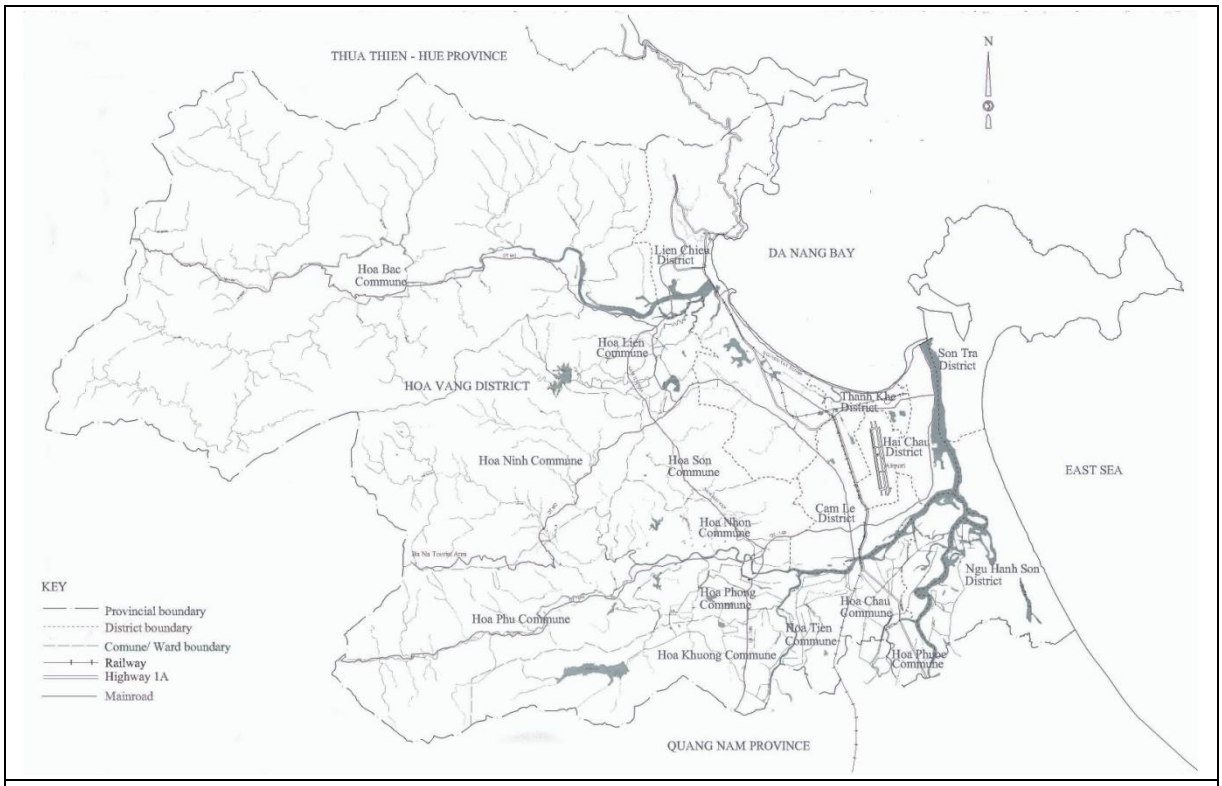


Figure 6. Boundary and Districts of Da Nang City

69. The terrain includes flat land and low hills to the south and east, and mountain ranges in the north and west. The mountains have elevations between 700 to 1500 masl while the coastal plains are fairly flat. The districts of Hai Chau, Than Khe, Cam Le and parts of Hoa Vang are situated on the coastal plain with average elevation of 2 to 2.5 masl. The Son Tra district is located in a mountainous peninsula with elevations from 5 up to 600 masl.

70. Da Nang has a tropical monsoon climate. The rainy season is from September to December, and the dry season from January to August. From rainfall measurements taken in 2004 to 2007, rainfall during the (four-month) rainy season accounted for 55 to 80% of the annual total. Average annual rainfall in the mountainous areas is about 3,000 mm, and in the coastal plain areas about 2,000 to 2,500 mm. Maximum rainfall of 592 mm in a day was recorded on 3 November 1999. Average humidity is about 80%.

71. Average annual temperature is 26˚C, with mean temperatures varying from lows of about 21˚C in December and January, and highs of about 30˚C between May and July (with maximum temperature recorded at 39˚C).

B. Population and Land Use

72. In 2008, the population of Da Nang was recorded at 822,178. 713,926 were living in the six urban districts, and 108,252 were living in the rural district of Hoa Vang. Historically the population growth over the five years leading up to 2008 was 1.7%. However city planners do not regard this as a reliable growth rate in projecting the city's future population. City planners anticipate that the recent rapid expansion of Da Nang's economy will continue and will establish the city as an economic center projecting from the central Vietnam into Indochina. Under this scenario, policies being promoted by the Da Nang and Central Region Integrated Strategy Study (DACRISS) are premised on a future population reaching up to 2.5 to 3 million.

73. In view of the above considerations, the city's future population rate has been re-assessed at a more realistic growth rate of 2.5% per year. An assessment of the unregistered population consisting mainly of students and migrant workers has been included in the latest population projection. On this basis the population is currently projected to reach 1.38 million by year 2025.

74. In terms of population density, the central district of Thanh Khe ranks highest at 176 persons per ha, followed by the adjacent Hai Chau district at 91. The average population density in the six urban districts is 28 persons per ha, compared with 1.5 in the two rural districts. City planners envisage a sustainable population density at 60 to 90 persons per ha. As the population densities in Thanh Khe and Hai Chau are thought to have reached saturation, future population increases are expected to take place mainly in the four other urban districts of Son Tra, Ngu Hanh Son, Lien Chien and Cam Le. Between 2005 and 2020, an increase in population of about 380,000 is projected in these districts. Urban construction land (e.g., public works) is projected to increase from 8,000 ha in 2005 to 11,845 in 2020. Over the same period, residential land is projected to increase from 4,300 to 6,500 ha, and industrial land from 610 to 1,500 ha.

75. Between 1997 and 2003, there was a significant increase in land conversion from agriculture to urban use, in particular for residential and commercial development. The area categorized as urban land increased by 17% during this period, with residential land increasing by 390 ha.

76. The city's urban expansion is expected to accelerate in the northwest and south corridors. However, the city's master plan has given priority for development in the northwest area traversed by Highway 1A because the trunk road network there is already in place. This urban expansion area is targeted to be served by the proposed water supply expansion project using the Cu De River.

77. The areas classified as forest land cover 67,148 ha (53% of the city's total area), mostly found in the western part of Hoa Vang District. The area designated for specialized forestry covers 22,745 ha (with 70% existing forest cover); 20,895 ha designated as protected forest (with 84% actual forest cover); and 23,508 as production forest (with 77% existing forest cover). These forested areas are largely found on sloping and rugged terrain.

C. Surface Water Resources

78. The city's main rivers are the Cu De River in the north and the Han River with its tributaries in the south. The water levels in these rivers are significantly affected by floods during the rainy season (September to December), and by sea tides during the dry season (March to August). The sea tides also increase the salinity level in the rivers.

79. Sea level measurements at Son Tra station between 1977 and 2004 show annual average sea levels from +0.80m and +0.90m during the dry season, and from +0.98m and +1.20m during the rainy season.

80. There are four main rivers that traverse the city, some of which are currently being tapped for water supply and others envisioned to supply Da Nang's growing water demand:

- The Cu De River which enters the sea to the North of Da Nang;
- The Cau Do River which originates from the south-west and joins the Cai River to form the Han River which flows south-to-north through the centre of the city;
- The Yen River which is branches off from the Ai Nghia River, which in turn is a branch of the Vu Gia River. Downstream of the An Trach barrage, the Yen River merges with the Tuy Loan River to form the Cau Do River;
- The Tuy Loan River which arises entirely within the city's area of jurisdiction and joins the Yen River as described above; and

81. The rivers start from the spine mountains and tend to flow either east-to-west or north-to-south. They are formed from mainly intrusive and extrusive volcanic rocks that have medium to hard crushing properties and provide ideal dam foundations and building materials. Drainage has created steep-sided V-shaped valleys especially where rivers have cut north to south along the fault lines.

82. During the four-month rainy season from September to December, the mean river flows are some five times larger than in the dry season. The region experiences typhoon rainfall on average 3 to 4 times a year when daily rainfalls of up to 650 mm have been recorded. Intense rainfall from extreme weather events cause widespread flooding in the low-lying coastal floodplain. Also during the wet season, the rivers carry high sediment loads. In the dry season, flows are much diminished and have higher concentrations of human, agricultural and industrial pollutants.

83. A groundwater study in the coastal area between Da Nang and Hoi An in 1978-87 showed that the groundwater system had low transmissivity and yield. Many households use shallow wells to supplement piped water supply from DAWACO. In areas unserved by piped water, wells are the main source; well water is usually boiled first if used for drinking. Many industries rely on deep wells. Because of the coastal location, excessive groundwater abstraction has induced saline intrusion into the aquifer. Future sustainable groundwater use is expected to be earmarked for rural communities, with industries targeted to for shift to surface water sources through the city's expanded water supply system which draws water from the rivers.

84. The Cu De River, which is the source of water for the proposed project, originates from the north-west mountain region of Da Nang. The main river flows west-to-east with the outlet at Da Nang Bay. There are two tributaries: the Bac River and the Nam River. Both rivers cut through steep-

sided gorges. At the flow gauge station in Nam My, the Cu De River covers a catchment area of 257 km^2.

85. The Cu De River has been programmed and approved by the DNPC for hydropower development by GERUCO; the scheme will feature a series of dams across the upper river segments which will also provide dry season storage that can be used to augment dry season flows in the Cu De River below. The planned main reservoir at Bac-2 River will have a catchment area of 129 km^2. As agreed between the DNPC and GERUCO, this reservoir (originally intended for power generation) will also serve as source of drinking water for Da Nang.

86. The Cau Do River is a deltaic branch of the very large Vu Gia and Tu Bon river basin which originates in Quang Nam Province to the south. The Yen River connects the Vu Gia River with the Cau Do River. It is the present source of raw water for Da Nang (discussed in the next section).

87. The Tuy Loan River system is a tributary sub-system of the Cau Do River which originates from the mountains directly to the west of Da Nang. Its four main tributaries are relatively short and can only provide limited quantities of water during the dry season. The observed large amount of spring-water flows into the Lo Dong River suggests that the groundwater catchment extends well beyond the river's surface catchment boundary.

D. Existing Water Supply Source

88. The present source of water for Da Nang is the Cau Do River. Its main source comes from the Vu Gia River which has a sizable catchment area (5,900 km^2). For extended periods of the year, however, the flow from the Vu Gia River (through the Yen River) is highly turbid.

89. A potential threat to water supply sustainability is the rapid pace of hydropower development in Quang Nam province. Some of the dam construction schemes there would involve inter-basin water transfers which will remove water from the Vu Gia River – in particular, in the case of the Dak Mi 4 dam. When fully operational, the latter will transfer 10 m3/s or 22% of the Vu Gia River's average dry season flow to another basin (by-passing Da Nang). This has been presented in various commentaries as a serious threat to Da Nang's water supply.

90. A Strategic Environmental Assessment on the Quang Nam hydropower plan (ADB, January 2008) proposed that the design of the Dak Mi 4 dam be modified to provide a gate for releasing dry season compensation flows. However, this has not happened. It appears overall that that dam proponents in the Vu Gia and Thu Bon river basins assume that they are not required to support downstream channels with dry season compensation flows. As such, there are inadequate provisions for dry season compensation flows from the numerous dams to be constructed on the Vu Gia river system.

91. Demand for irrigation water from the Song Vu Gia is also projected to increase, which would intensify the competition for dry season flows. According to the SEA Report cited above, the present irrigation water demand of 1,200 million cubic meters would increase to 1,500 by 2020.

92. The reliability of dry season river flow to Cau Do through the Yen River is also at risk due to natural morphological changes in the Vu Gia River. As it approaches Da Nang, the Vu Gia River flattens into an unstable braided system. And in what appears to be a natural process, the meander

channel feeding the Yen River was short-circuited during a flood in 1999 resulting to most of the flow spilling into another basin and by-passing the Yen River, thereby reducing dry season supply to Da Nang. Although the breakthrough channel has been repaired in order to restore flow to Da Nang, the repair works would remain under constant threat from the shifting geometry of the river.

93. With an expected reduction in dry season flows from the Song Vu Gia, the existing water supply intake at the Cau Do WTP would be more vulnerable to salinity intrusion and increased concentration of pollutants as a result of the river's reduced flushing capacity. The early onset of the dry season in 2010 has forced DAWACO to pump water from An Trach due to salinity intrusion in the Cu De River, in turn attributed to inadequate freshwater flows from the Vu Gia River.

94. Apart from reliability threats to the present water supply source during the dry season, there is also a water quality risk posed by mining operations in the tributaries of the Vu Gia River. Intensive mining activity is taking place in the basin, and Quang Nam province's development master plan (up to 2015) points to mining as of one of three main industries to be promoted. Mercury is used by numerous artisanal and small scale miners operating on or near the riverbeds to extract gold (bigger gold mining operations use Cyanide). Thus, heavy metal contamination from these mining areas in the Vu Gia basin is a potential threat. In addition, mining activities increase water turbidity. Indeed, the flow going into the Yen River from Vu Giu is very turbid even in the dry season

E. Water Demand

95. Water demand is projected to reach 255,000 m^3/day by 2015 and 500,000 m^3/day by 2025. Current water production capacity is only 205,000 m^3/day. Water demand has been increasing at about 15% annually, with the highest increase from domestic and commercial users. Water production has been increasing at 10% annually, but has lagged behind the rapidly growing demand. Table 4 shows the actual water consumption by sector from 2007 to 2008.

Table 4. Water Consumption According to User Type

User	Consumption in m^3/day			
	2007		2008	
Household	48,715	72%	56,395	73%
Commercial	4,727	7%	5,876	8%
Industrial	7,266	11%	7,832	10%
Governmental	6,772	10%	6,997	9%
Total	69,487		79,108	

96. The number of service connections increased from 84,550 in 2006 to 117,400 in 2008, and the population served in the DAWACO service coverage area increase from 48.4% to 55.3% during the same period.

97. Efforts to reduce non-revenue water have been producing good results, as a result of a program to replace old leaking pipelines, metering, and improvements in network zoning and operation. Ongoing interventions to reduce water losses have already brought about a reduction in non-revenue water from 38% in 2005, 35% in 2008, and 32% in June 2009--with the target set at reaching 20% by year 2020.

F. Water Quality

98. River water quality analyses for 42 parameters prescribed under Vietnam's regulations were conducted for 10 sites within Da Nang during July 2009 (coinciding with dry season) and November 2009 (wet season). The rivers and reservoirs sampled, and their locations, are shown in Figure 7. The test results were compared with National Technical Standards QCVN 08:2008/BTNMT for surface water quality on the basis of Decision 16/2008/QD/BTNMT issued in December 2008 by the Ministry of Natural Resources and Environment. Results of the surface water sampling are shown in Annexes 2 to 3.

99. Water quality in the Yen River which supplies the existing Cau Do WTP through the pumping station at An Trach shows quite significant turbidity. For instance, in the July 2009 (dry season) water quality sampling of the Yen River, the TSS concentration found was twice the national standard for surface water quality. During the (rainy season) November 2009 sampling, the turbidity was measured at 86 mg/l which was nearly three times in excess of the standard; and COD was also high (42 mg/l, nearly three times the standard).

100. Drinking water samples were taken from 5 points in the present water supply service areas of DAWACO (labelled A to E in the map shown in Figure 4). All of the sampled sites are supplied from the existing WTPs that obtain raw water from the Cau Do River. The quality of the drinking water samples is similar in being soft as indicated by conductivity values of 86 to 92 µS/cm (equivalent to a TDS value of approximately 60 mg/l and hardness of about 6 mg/l $CaCO_3$). Test results, shown in Annex 4, were compared against standards set for drinking water quality under TCXDVN 33:2008/BXD and found to be in compliance.

1. Bac River	6. Yen River
2. Nam River	7. Tuy-Loan River
3. Middle part of Cu De River	8. Dong Nghe Reservoir
4. Lower part of Cu De River	9. Lo Dong River
5. Cau Do River	10. Hoa Trung Reservoir

Figure 7. Sampling locations for water quality

101. Specifically for the Bac River—the raw water source for the proposed project—the July 2009 and November 2009 water samples had values for the 42 water quality parameters that were below the limits of the national technical standards for surface water. [3]

102. From the test results, water in the Bac River is assessed to be reasonably well oxygenated. Nutrient content is low, hence the potential for algal growth is low. There is no significant evidence for the presence of sewage or agriculturally-derived pollution based on the values measured for BOD and COD. As for 12 metals tested, only iron was detected at a concentration (0.05 mg/l Fe) above the limit of detection for each of the metals.

103. Surface active detergents and oils and greases were not detected at their respective limits of detection. Phenols were present but at concentrations significantly below the standard (0.005 mg/l). In addition, analyses were carried out for 8 organo-chlorine pesticides, 2 organo-phosphorus compounds (Parathion and Malathion), and the herbicides 2,4 D; 2, 4, 5 T, and Paraquat. None of these were present at their respective limits of detection. Radioactivity levels were reported at concentrations well below the European standard values for good quality surface raw waters.

104. The bacteriological quality of the raw water was found to be moderately good with an MPN for E. Coli of 7/100ml and 240 /100 ml for total Coliform. The corresponding Standard values for A2 waters are 50 and 5000/100 ml. This supports the observation that the water at the Bac River is of fairly good organic quality with little evidence of pollution from sewage or agricultural practices.

105. For the lower part of the Cu De River (near the estuary), results of water quality testing for key pollution indicators (plus Chloride as an indicator for salinity intrusion) show significantly high values relative to national standards for surface water, in particular for the dry season water sample Table 5). Observed sources are effluent from the aquaculture ponds that line the estuary banks, and sewage from upstream riverbank settlements. Tidal mixing has a mitigating effect in diluting pollution levels.

Table 5. Water Quality of the Lower Cu De River

Parameter	Unit	Sampling Results		Surface water standard
		July 2009	Nov 2009	
COD	mg/l	260	60	15
BOD_5	mg/l	68	10	6
Ammonium-Nitrogen ($N\text{-}NH_4$)	mg/l	0.60	0.18	0.20
Chloride	mg/l	7100	1400	400
Nitrite ($N\text{-}NO_2$)	mg/l	0.03	0.03	0.02
Nitrate ($N\text{-}NO_3$)	mg/l	12	3.1	5

106. As part of the baseline environment survey conducted under the PPTA, water samples were also collected from the vicinity of the pipeline construction and the site for the water treatment plant at Hoa Lien. The samples were analysed by the DONRE Environment Protection Center

[3] The exception was Ammonia-Nitrogen which was reported in the July 2009 sampling at 0.45 mg/l compared with the standard of 0.2 mg/l. This was later found to be due to laboratory error. Supplemental testing was done in September 2009 for sixteen key parameters. All had results below the limits set by standards. Ammonia-Nitrogen was measured at 0.12 mg/l, well below the standard limit of 0.2 mg/l, confirming that the earlier result on this parameter was erroneous.

laboratory; the results are shown below, along with the water quality criteria set under TCVN 5911-1995 for surface waters. Water quality was found to be generally of good quality.

Table 6. Surface Water Samples in Vicinity of Pipeline Corridor and WTP Site

Parameter	Unit	Sampling Results			Criteria under TCVN 5943-1995
		Loc1	Loc2	Loc3	
pH	-	7.3	7.4	7.5	5.5- 9
Colour	PtCoApha	10	8	5	-
Turbidity	mg/l	15	11	7	-
TSS	mg/l	16	11	3	80
BOD_5	mg/l	6	4	NF	< 25
COD	mg/l	8	6	5	< 35
Coliforms	MPN/100ml	$23x10^2$	$23x10^2$	420	10,000
Lubricant	mg/l	0.3	0.3	0.3	0.3
Hg	mg/l	0.0007	0.0005	NF	0.002
As	mg/l	0.036	0.0017	NF	0.1
Cd	mg/l	0.0009	NF	NF	0.02
Pb	mg/l	0.0035	0,0045	0.0021	0.05
Zn	mg/l	0.0279	0,0283	0.0091	2

Loc1: Water sample taken from Gia Tron canal, close to the dam outlet
Loc2: Water sample taken from Gia Tron canal going to the Cu De River
Loc3: Water sample taken from Cu De River
NF – not found/detected

107. For the groundwater in the project area, sampling tests gave the following results. Except for the Coliform count (indicating possible contamination from nearby septic tanks or drainage water leakage into the shallow wells), water quality parameters were below the limits set in the standard.

Table 7. Groundwater Samples in Vicinity of Pipeline Corridor and WTP Site

Parameter	Unit	Sampling Results			Criteria under TCVN 5944-1995
		N1	N2	N3	
pH	-	6.8	6.7	6.7	6.5 – 8.5
Colour	PtCoApha	NF	NF	NF	5-50
Turbidity	mg/l	1	2	4	45
Hardness	mg/l	55	57	60	300-500
TDS	mg/l	294	445	219	750 – 1,500
NO-3	mg/l	5.1	5.7	6.2	45
S2-	mg/l	0.002	0.003	0.002	-
Coliforms	MPN/100ml	60	19	43	3
Lubricant	mg/l	NF	NF	NF	-
Hg	mg/l	NF	NF	NF	0.001
As	mg/l	NF	NF	NF	0.05
Cd	mg/l	0.0026	0.0005	0.0006	0.01
Pb	mg/l	0.006	0.0032	0.004	0.05
Zn	mg/l	0.0089	0.0078	0.018	5.0

N1: Well-water sample taken from a well Cell 11, Hoa Hiep Nam-Lien Chieu
N2: Well-water sample taken from a well Cell 21, Hoa Hiep Nam-Lien Chieu
N3: Well-water sample taken from a well Cell 21, Hoa Hiep Nam-Lien Chieu
NF – not found/detected

G. Catchment Condition

108. The mountainous portions of the city have steep sides that are generally covered by secondary forest. Much of the primary forest appears to have been logged or otherwise destroyed (apparently during the Vietnam war). Nonetheless, the secondary growth appears thick and effective at preventing erosion. Much of the mountain catchments are within the Ba Na Nui-Chua nature reserve where development is more strictly controlled, although there is reportedly some illegal mining of gold taking place in the upper reaches of the Nam River (along the border with Quang Nam province). Human settlement in the valley bottoms is having an effect on river water quality especially where steep slopes are cultivated causing erosion problems.

109. The hillsides upstream of the river systems in Da Nang are planted with pulpwood species (*Acacia auricoliformis*) that are clear-cut during harvesting (Figure 8). The exposed ground after clear- cutting is vulnerable to erosion and landslides. Actively eroding riverbanks add to the build-up of sediment deposits in the river systems and increased water turbidity.

Figure 8. Clear-cut areas used for forest plantations

110. Gold mining activities are mostly found in neighbouring Quang Nam province (the main catchment of the Vu Gia River which approaches Da Nang from the south). Mercury is used in gold extraction. Since the technique is easy to use, the method is preferred especially small-scale (legal and illegal) miners. Mercury readily binds with sediment and, therefore, it is hard to detect in the water column itself. This could be why a 2006 EIA study for the Song Bung 4 dam in Quang Nam province reported that Mercury levels in the water at all sampling stations, even those located just downstream of an ongoing gold mining activity, were low compared with water quality risk standards.

111. On the other hand, studies by the Quang Nam DONRE report that Mercury levels in the affected river systems in Quang Nam have increased and have already exceeded the acceptable threshold in some parts of the province, and that these are likely caused by the gold mining activities.

112. Floating gold dredging machines that scour the river beds (or small-scale miners who dig up the river banks) for the gold-bearing sediments dump the processed sand and gravel along the banks or in small creeks and tributaries. This results in murky river water when floods sweep the spoils

downstream. This would partly account for the high turbidity of the water flowing into the Yen River from Quang Nam Province.

113. Small-scale illegal gold mining is reportedly taking place in the remote upper reaches of the Nam River catchment, which lies within Da Nang. Access to this area is probably through the nearby gold mining areas in the Vang River across Da Nang's border with Quang Nam province.

H. Ecological Conservation Areas

114. There are three nature conservation areas inside Da Nang: (a) Ba Na-Nui Chua nature reserve, (b) Son Tra nature conservation park, and (c) Southern Hai Van Pass. The most important of the three, from the standpoint of water supply protection for Da Nang, is the Ba Na-Nui Chua reserve.

115. The Ba Na-Nui Chua nature reserve covers 8,838 ha; its boundaries are inside Da Nang's jurisdiction (Figure 9). Within the reserve, 3,589 ha have been designated as a strict protection area, 5,189 ha as rehabilitation areas, and 70 ha as administration and service areas. The nature reserve is centered on Mount Ba Na (peak elevation: 1,487 m) which is part of the mountain ridge that stretches across central Vietnam from the Annamite mountains in the west to the Hai Van Pass in the east.

Figure 9. Boundary of the Mount Ba Na-Nui Chua Nature Reserve

116. Although connected to the Annamite mountain ridge, the Ba Na nature reserve's montane habitats are separated from the ridge by intervening areas of lower elevation. The main natural vegetation types found in the reserve are lowland evergreen forest (Dipterocarpaceae family) and lower montane evergreen forest (Lauraceae, Fagaceae and Podocarpaceae families). There are 472 vascular plant species recorded, 29 mammal species, 106 bird species, 20 reptile species, 6 amphibian species, 33 fish species and 126 butterfly species.

117. Streams and river tributaries originating from the north-west side of the reserve feed the Cu De River (and the Bac and Nam river tributaries), while those originating in the south and east parts of the reserve serve as source of streams that partly feed the Lo Dong River. The protected status of the reserve is advantageous for protecting the water quality of the rivers used to supply Da Nang's water needs.

118. The Son Tra nature conservation park, located in the Son Tra peninsula east of Da Nang, covers 4,439 ha with 77% forest cover. The park features a combination of coastal ecology and tropical forest ecology with diverse flora. Its forest catchment is the source of recharge for two springs and runoff capture ponds that supply water to a limited area in the north-east part of the city. The peninsula itself protects the city from tropical storms, and the park's attractive landscape and historical relics make it an important tourism site.

119. The Southern Hai Van Pass (north of the city) covers 10, 850 ha which is about 90% covered with natural and planted forests. The area provides an important forest corridor that connects the coast to the Annamite mountains in the west and the Bach Ma national park in the north (Hue Province), and has an important role in biodiversity conservation.

V. IMPACTS, ALTERNATIVES AND MITIGATION MEASURES

A. Expected Benefits

120. Overall, the benefits of the project are significant in terms of meeting projected growth in water demand and shifting household water supply from non-piped to piped sources. Based on the PPTA economic analysis, the full cost to residents of non-piped water is greater than the cost of piped supply. The PPTA household survey results revealed that the average household in Da Nang consumes about 104 lpcd from the DAWACO piped water system, and an additional 43 lpcd from non-piped sources. The total compares reasonably with the survey data on water consumption of households not connected to DAWACO, i,e., 148 lpcd.

121. In Da Nang, almost all non-piped water consumption is well water which needs to be pumped, and filtered or boiled first for drinking use. Because of rapid urbanization and expansion of industries, the risk of contamination to shallow water wells could rise.

122. The main benefit of the proposed project is decreased supply costs to consumers as a result of shifting from non-piped sources (i.e., shallow wells in the case of Da Nang) to a piped water system under DAWACO. According to the PPTA economic analysis, the construction of the new WTP at Hoa Lien (including the refurbishment of the Cau Do facility) would generate direct user benefits valued at $54 M (NPV at 2010 prices). Indirect user benefits are also significant; they include: (a) cost savings of $11.8 M due to shifting from well water to DAWACO water for existing customers (non-incremental water); (b) value of the incremental water supplied, $6.4 M; and (c) value of *health* benefits, $40 M, which is considerable. The EIRR is 15.6%.

123. The discussion that follows focuses on a number of potential adverse environmental impacts of the project —mainly associated with construction works and operation--and corresponding options, safeguards and mitigation measures. The assessment is presented in three sections: (a) raw

water pipeline from the Bac River dam intake to the water treatment plant; (b) water treatment plant at Hoa Lien; and (c) water supply distribution system. For each section, the discussion of impacts and mitigation measures is presented with regard to project construction and operation phases.

B. Pre-Construction Activities

124. The pre-construction activities under the Project (for the raw water pipeline, WTP and distribution network) are related to the construction of the Soc Bac hydropower dam which will supply the raw water to the Project.

125. As explained in the introduction to the IEE report, the hydropower dam is an existing project which had earlier been approved for implementation by the Government in 2007 and then subsequently renegotiated with the project developer (GREUCO) to also serve as a water supply source for Da Nang. The dam's viability and existence, as such, do not depend exclusively on providing raw water for the proposed water supply project. Thus the dam is not considered an Associated Facility of the current project and is not covered in this environmental assessment.[4]

126. Since excavation related to infrastructure development is one of the main causes of accidental detonation of unexploded ordnance in Vietnam, and given the proximity of the excavation work sites to populated areas, care must be taken to ensure that the pipeline route is surveyed for presence of unexploded ordnance prior to construction. If such ordnance are detected and verified, clearing work will need to be commissioned, following established procedures under the National Mines Regulatory Authority, prior to undertaking any civil works. (A budget for this pre-construction survey work is provided in the environmental management plan.)

[4] The government's previous approval for construction of the Song Bac dam was supported by an EIA prepared by the project proponent and cleared by the DONRE in accordance with Vietnam's EIA regulations.

C. Construction Activities

127. The environmental impacts associated with construction activities, notably for the raw water pipeline and the WTP, are largely influenced by the location and nature of the construction works—in particular, the excavation of the 16.5 km pipeline trench. The available corridor for laying the raw water pipeline is geographically limited by the space along Highway 601 which traverses a narrow area bounded by the erodible banks of the Cu De River on the north side and by steep hills on the south side. To avoid being scoured by the river during floods, the pipeline will generally be positioned between the road and the hillside, unless the hillsides are too close to the road, in which case the pipeline will be buried under the road bed.

128. The roadsides where the pipeline trench will be excavated are inhabited, and the settlements become dense as the pipeline approaches the WTP site. As such, excavation activities will happen close to the where people live, causing disruption or dislocation as well as various kinds of nuisance effects, including the potential for improperly stored excavation spoils to impair water quality in the nearby river. Since the construction space is very narrow, the option of placing the pipeline under the road in order to avoid damaging or dislocating adjacent residential structures is infeasible. Cutting off the traffic in order to lay the pipeline under the road bed would be extremely disruptive to the local community, as the highway is the only road access to the inhabitants of the Cu De Valley. These location characteristics provide the basis for the assessment and mitigation measures described below.

129. Two options were considered for the construction of the raw water pipeline, based on a planning assumption that the water supply development is to be implemented in two phases, each phase involving provision of 120 m^3/day supply capacity. The first option is to build the 16-km pipeline according to the timing and capacity requirements of each phase. Thus, phase 1 (construction beginning 2011) will involve laying a first pipeline (1 meter diameter), and phase 2 (beginning 2021) will involve laying a second pipeline of the same size. The second option is to build the pipeline such that it is already sized to the total capacity of the two development phases. This means that the pipeline will already be sized for 240,000 m^3/day supply capacity at the start of phase 1, i.e., 1.4 m pipe diameter. The pipeline will be buried with a clearance from top-of-pipe to ground level of at least 1.2 m.

130. In terms of both least-cost considerations and environmental impact, the option of building one large-diameter pipeline to match the capacity requirements for the two phases is the most advantageous. This option will entail the least amount of land disturbance, i.e., 6.4 ha, assuming a 4-m wide working corridor for the pipeline trench (the trench itself will be about 2 meters wide). By comparison, Option 1 above will require 8.8 ha.

131. A disadvantage of the preferred (large) pipeline option lies in: (a) the economic opportunity cost of the excess capacity in the intervening period between phases 1 and 2; (b) the issue of whether there may be alternative water supply options that can deliver phase 2 water requirements at a lower incremental cost, e.g., expansion of the Cau Do facilities if water security and quality issues associated with the Vu Gia River source are resolved; and (c) some uncertainty surrounding the reliable capacity of the Bac dam reservoir source to deliver the full supply requirement year-round.

132. Near the Sap Bridge at the Nam River, the pipeline coming from the dam will cross the river through a trench constructed across the riverbed. Since the riverbed material at this location consists of gravel and rocks, it is not expected that the construction work will result to excessive turbidity of the water downstream. Construction will be done during the summer months when the reduced volume of river flow can easily be diverted.

133. For the remainder of its length (Figure 10), the pipeline will be positioned between the road and the hillside shown in the imagery above. This alignment would protect the pipeline from possible effects of riverbank scouring or bank collapse on the side of the road facing the Cu De River. From the edge of the road side drain/ditch, a 4-m wide corridor will be used to lay down the pipe trench. In some parts, excavation work will entail cutting into the slope of the bordering hill; in other parts, this will entail crossing through the front yards of houses and establishments along the route.

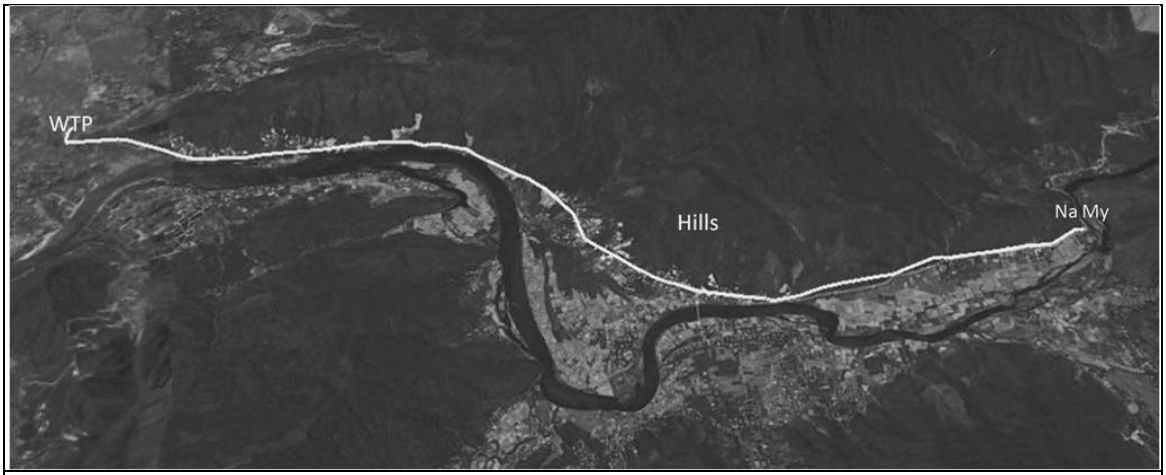


Figure 10. Alignment of raw water pipeline along existing road (view toward south)

134. The area disturbance could be mitigated by placing the pipeline under the existing roadbed. However, this is not feasible because the road width is narrow (only 3-4 m wide); excavating the road would completely cut off the traffic in the area. In any case, the road needs to remain unobstructed to provide space for access to the trench excavation works and for the movement of equipment and construction materials.

135. Laying pipelines of the size specified for the project would typically require an easement of up to 15 meters wide in order to provide enough space for movement, pipe trench excavation, and temporary storage of excavated materials. However, such a width is not available for considerable lengths of the pipeline route where the distance between the road and the bordering hillside, or between the road and the adjacent houses and establishments, is less than 5 meters. As such, the excavation and handling of excavated material, in particular, need to be properly managed to prevent obstruction to paths or alleys used by the community, or silting up of drains from eroding piles of excavated soil, or creating nuisance caused by dust from dry mounds and movement of dump trucks.

136. Use of temporary spoil storage sites for extended periods should be avoided, and the mounds should be watered regularly to prevent excessive dust production. At construction areas close to streams, silt traps should be used to prevent sediment build-up and excessive water turbidity.

137. A large fraction of the excavated material will be used to backfill the trench after the pipes are laid. As such it is not expected that an excessive amount of spoils from the pipeline construction will need to be disposed. In any case, the final disposal areas for the excess spoils should be carefully sited so that these are not vulnerable to flooding, and are located on stable slopes to prevent slumping. If possible, the disposal areas should be covered by topsoil and re-vegetated. Around the disposal areas, adequate drains should be installed. The excavation spoils should be treated as a resource and their possible beneficial uses maximized—for instance, as base material if suitable for raising road-top levels in flood-prone sections, for filling in of areas being developed for settlement use, or for constructing or improving protective riverside embankments.

138. Tender documents for the pipeline construction should include provisions to prevent improper handling of spoils. Contractors should explain the excavation methods to be used and the measures for handling spoils. Before areas are designated for spoils temporary storage or final disposal, the contractor should examine the physical suitability of the sites and also assess alternative beneficial uses of the material. The soundness of the measures should be part of the selection criteria for awarding construction contracts.

139. Because of the narrow road width, and the crowded conditions in some sections of the pipe route, the impact on local traffic could be significant. As it may not possible in the narrow sections to store the excavated earth on the road itself without blocking traffic, the material would have to be transported to a designated storage site first and, when needed to back fill the trench, would be transported back to the work site. As such, there could be frequent movement of trucks transporting earth material along the road.

140. In view of nearby residential areas, nuisance impacts from earth hauling activities such as noise, exhaust fumes and dust need to be mitigated. Dump trucks carrying spoils need to be cleaned regularly, and their emissions checked for compliance with standards, particularly for particulates. During the dry season the transport route near residential areas should be sprayed with water to prevent excessive dust.

141. To minimize construction impacts overall, work schedules should be well-planned and activities during rush hours near schools and markets should be minimized. Construction and transport equipment used should be of appropriate sizes to fit the limited work spaces; durable wooden or steel plates should be used across trenches and drainage ditches to provide temporary crossings for pedestrians and motorcycles; construction and materials storage sites should be adequately lighted at night; open trenches must be fenced and clearly marked; and adequate sanitation facilities for workers should be provided at the work sites. Contractors must avoid activities producing loud noise and vibration if there is night time construction work necessary.

142. To a large extent, these safeguards are not unique to the project and are provided for in existing government decrees and codes of practice regulating construction work. Tender documents for construction should, therefore, require adherence to safeguards as specified in existing laws and regulations, with provisions for calling on the contractor's performance bond as sanction for violations.

143. Overall, the most significant effect of the pipeline construction is the disruption or damage to property caused to the resident population. The construction of the pipeline along the inhabited

sections will inevitably affect existing houses, farms, and some public buildings. However, it is important to emphasize that only a few households will need to be relocated, since the roadside residential areas traversed by the pipeline are mostly the front yards of the houses. Where houses are too close to the road and will be damaged by the pipeline construction, the owners will be compensated so that their houses can be moved farther back from the roadside.

144. Even though, under a DNPC decree issued in October 2005, provincial roads are to be provided with a 15 m easement or safety corridor to both sides, the existing households along the road and pipeline alignment have long lived there and, consequently, have legal land use rights. They will have to be compensated if parts of their lots are recovered by the government or if portions of their houses are damaged due to the construction works.

145. Based on the survey of households and farms along the pipeline route, 195 households will be affected by the "recovery" of roadside areas to be traversed by the 4-m wide pipeline corridor (covering a total of 6.4 ha). The term recovery is used here to mean that the government will pay affected parties (residents and farmers) to gain complete and permanent control of the pipeline corridor. In terms of size, 2.88 ha of the pipeline corridor will require compensation for the recovery of the area; the remaining 3.58 ha to be recovered will not require compensation as these are currently public lands.

146. The estimated cost of the compensation package for affected households, commercial establishments, and farmers along the raw water pipeline corridor is 5,360 million Dong ($290,000).

147. A detailed discussion of the dislocation impacts due to construction of both the pipeline and the water treatment plant, including the corresponding compensation and relocation measures to be instituted, is presented in a separate report focused on resettlement and compensation issues, following ADB guidelines (Appendix 16 of the Draft Final Report, i.e., Resettlement Framework).

148. No historical relics will be demolished or relocated by the pipeline construction.

149. A minor impact could be lowering of water levels in the shallow wells used by some households located on the side of the road across the pipeline. This is because the pipeline trench could intercept the groundwater table from the mountain (recharge) areas toward the river. However, such water table lowering effect near the open trenches during construction is not expected to cause the shallow wells to become permanently unusable.

150. It should be noted that the environmental impacts described above are temporary in nature, i.e., during the two-year construction period for the pipeline. The pipeline operation itself is not expected to produce adverse effects, and indeed, a benefit of the pipeline corridor created is that it will provide space for future widening of the provincial road.

151. The raw water pipeline construction (and that of the WTP) will not have a significant impact on the flora and fauna, as the construction activities will take place in existing agricultural and settlement/urban areas.

152. The lay-out of the water distribution network consists of the transmission pipeline from the water treatment plant (including the refurbished facility at Cau Do), the main pipelines to the district service areas newly served or expanded, branch pipelines within the districts, then distribution and service pipes to end-users. The lay-out of the supply network conforms to the general plan for the development of Da Nang, projected up to 2025. The main and distribution pipelines from the WTP will be built along the roads (existing and planned) such that:

153. As for the construction or rehabilitation of the water distribution network, the locations are determined by the lay-out of the water supply network conforming t the general plan of development for the city up to 2025. The main and distribution pipelines will be built along the existing and planned roads, with the branch distribution pipes laid under the sidewalk pavement to minimize impact on traffic flow

154. As in the case of the raw water pipeline, the adverse impacts are related to the disruption and nuisance caused by construction activities on the nearby residential and commercial establishments.

155. Water distribution pipeline crossings at the two main rivers (Han and Cam Le) will be through existing or new bridges (subject to engineering assessments and depending on the size of the delivery pipes), or with the pipe supported by its own bridge structure. There are no plans to construct distribution pipelines under the riverbeds, e.g., inverted siphons, for mainly engineering and cost reasons. As such the potential adverse environmental effects of such construction method are avoided.

156. The same mitigation measures and safeguards as those earlier discussed for the raw water pipeline construction should be applied for the development of the distribution network, summed up below:

- Manage excavation and pipe-laying activities so as to avoid unnecessarily blocking streets or alleys used for mobile and pedestrian traffic;
- Use of temporary spoil storage sites for long periods should be avoided, and (in the dry season) the mounds of spoil should be watered regularly to prevent excessive dust production.
- A large fraction of the excavated material will be used again to backfill the pipeline trenches, and so the excavated soil will be placed on the side of the road until needed for backfilling. Temporary earth piles placed along the roads and pavements should be managed in order to avoid silting up drains/ditches or creating nuisance caused by dust. At construction areas close to streams or canals, silt traps should be used to prevent clogging the drainage system.
- Disposal areas for the excess excavated soil should be properly sited so that these are not vulnerable to flooding or slumping. If possible, the disposal areas should be re-vegetated. Around the disposal areas, adequate drains should be installed.
- Excavation spoils could be treated as a resource and their possible beneficial uses maximized. As such excavated material is usable for various purposes, it is expected that the deposits in the disposal area will be removed/recovered over time.

- Tender documents for the pipe construction should include provisions to prevent improper methods for excavation and handling of spoils. Contractors should explain such methods which should be part of the criteria for awarding contracts.
- In very narrow streets, it may not be possible to store excavated earth on the road or pavement without completely blocking traffic. In this case, excavated material would have to be transported to a temporary storage site, then transported back to the construction site for backfilling. In this case, nuisance impacts from earth hauling activities such as noise, exhaust fumes and dust need to be mitigated. Dump trucks carrying spoils should be cleaned regularly, and exhaust emissions checked for compliance with standards, particularly for particulates.
- Noise from jackhammer operation or grinding of concrete or asphalt roads/pavements will be unavoidable, although the nuisance created will be temporary.
- To minimize construction impacts overall, work schedules should be well-planned and activities during rush hours near schools, hospitals, and markets should be minimized. Construction and transport equipment used should be of appropriate sizes in limited work spaces; steel plates should be used across excavated trenches to provide temporary crossings for pedestrians and motorcycles; construction sites should be adequately lighted at night; open trenches must be fenced and clearly marked; and portable toilets for workers should be provided at the major work sites.

157. In addition, project contractors should be required to comply with existing Vietnamese guidelines and regulations for the control of temporary nuisance impacts related to construction works, as listed in Table 9.

Table 9. Vietnam Laws and Standards for Regulating Construction Impacts

Relevant Aspect/Impact	Vietnam Guidelines and Standards
Dust emission	TCVN 5937:2005
Air emission from construction equipment and transport vehicles	TCVN 5947-1; TCVN 6438; TCVN 5939; TCVN 5940
Noise	TCVN 5948:1998; TCVN 5949:1999
Vibration	TCVN 7210:2002
Traffic obstruction	TCVN 4054:1998
Excavation heaps and spoil storage areas	TCVN 5299:1995
Effluent/discharge standards	TCVN 6984:2001
Hazardous substances	TCVN 5938:2005

158. To minimize disruption of water supply during the rehabilitation of existing connections, a detailed plan for phasing-in of the new water supply system will be prepared during the detailed engineering design of the project.

D. Project Operation

159. The raw water treatment process will basically involve two-stages: (1) clarification, and (2) filtration and disinfection. It is proposed to use tube settlers for the clarification stage, as used in a recently commissioned WTP at Cau Do. Following clarification, the plan is to use conventional rapid gravity filters for the second stage using sand media (around 1 m deep) and equipped with

conventional air-water washing. Aside from the conventional treatment units (receiving tank, reaction tank, settlement tank, filter tank, and clean water tank), other structures to be built are the chemical house, chlorine house, generator house, warehouse, pumping station, and administration office.

160. Chemicals to be used on a regular basis are poly-aluminum chloride (PAC) for flocculation, soda for pH control, and chlorine for disinfection. Of these chemicals, chlorine is the most hazardous if improperly handled. It is estimated that, when the plant is operating at its full 240,000 m^3/day capacity, the amount of chlorine required is 480 kg/day. The chlorine house is to be built to accommodate 20 chlorine containers, each containing 980 kg. At any given time, there will be 2 working containers.

161. Because chlorine is a very reactive and corrosive material, it can cause severe irritation if workers become exposed. In contact with water, chlorine can create a highly corrosive and dangerous acid mist. Therefore, storage and handling procedures are very important. During WTP operation, the chlorine storage house, storage containers, and associated process equipment need to be clearly marked. Chlorine containers must be kept moisture-free and stored separately from other chemicals.

162. Workers need to wear personal protective equipment such as splash goggles, face shields, gloves, coveralls, and leather boots when handling chlorine. They should be trained on safe work practices and emergency steps when handling the chemical. The plant's operating procedures should include an inspection and maintenance schedule for all chlorine storage and handling equipment, which should also be regularly checked for possible leaks.

163. Apart from the potential hazard associated with handling of treatment chemicals, disposal of sludge and wash water from the treatment process is the most important aspect of the WTP operation that can cause adverse impacts, specifically on the surrounding land and waterways. Sludge is a product of the sedimentation and filtration processes, and it consists of chemical floc, fine particles and reservoir-derived algae removed from the raw water through flocculation. The sludge contains the aluminium-based flocculating agent but is not toxic. The quantity of sludge produced from the Cu De WTP is not estimated to be large since the raw water comes from a reservoir in which sedimentation processes would have already removed most of the turbidity.

164. The clarifier sludge (produced as batch discharges from the plant operation) will have few potential beneficial uses, and provision needs to be made for disposal. There are two options for dealing with the sludge: (a) dewatering so that it can be handled easily and disposed as solid waste in a controlled landfill, or (b) discharge in liquid form into the river or spreading on open land.

165. The dewatering option has two variants: (a) mechanical pressing to thicken the sludge into cake, or (b) natural settlement and drying. For (a), sludge coming from the settling tank is first conveyed to a separate thickening tank, from where it then goes through a mechanical (plate) press to remove the water. The dewatering process converts the sludge into block/cake form which can then be easily transported to a landfill. Alternatively, for (b), the sludge and washwater would be piped to a lagoon or basin to settle, alternating the operation with a second basin to allow for settlement and removal. The thickened sludge is moved from the settling basin to a drying area, and then taken away to a landfill. This second variant requires more space.

166. The sludge in the regular batch discharges from the clarification process would normally contain up to 3% solids (by weight). After dewatering, the solids content would increase to about 25 to 30%, and the sludge would have the consistency of cake, which is easier to handle and transport to the landfill. It is estimated that around 10-15 m^3/day of dewatered sludge would be generated by the WTP.

167. As for the option of discharging to a stream, the sludge and wash water would be piped to the outfall from the clarifier and filters as turbid water. If dilution ratios in the receiving waterways of at least 5000:1 can be achieved (depending also on the river's uses), this disposal method need not cause adverse effects since the sludge mainly consists of inert silt and contains no toxic chemicals.

168. At the existing Cau Do WTP, the sludge is not discharged into the river directly---since the plant draws raw water from the same river. Rather, the sludge is allowed to settle in two alternating settling basins; then the thickened sludge is removed for disposal (as regulated by the Environmental Protection Center of the DONRE).

169. For the proposed Cu De WTP, the raw water comes from far upstream of the Cu De River. Nevertheless, discharging the treatment sludge into the river is inadvisable given the city's plan to develop it as a tourism attraction, in which case aesthetics and water quality would be an important consideration.

170. The remaining choice is dewatering of the sludge, either through plate pressing, or through natural settlement in a lagoon or tank (which will take up more space). This would be decided mainly on the basis of economy and efficiency considerations. As the technology for dewatering of sludge by means of plate pressing becomes more conventional, this option is to be preferred as a long term design feature of all new WTPs in Da Nang.

171. Table 8 shows the handling and disposal of other kinds of waste expected during the commissioning/testing and normal operation of the WTP.

Table 8. Mitigation of WTP Wastes

Stage	***Source of Waste***	***Nature of Waste***	***Treatment/Disposal***
During commissioning	*Hydraulic testing water*	*Usually free of contaminants*	*Discharge to the nearby water course (an existing channel leading to Cu De River)*
	Treated test water during the plant start-up and process adjustment	*Process water containing chlorine which may exceed the drinking water quality standard*	*Discharge to water course after dechlorination if necessary*
	Water used for disinfecting tanks	*High chlorine residual*	*Discharge into the nearby water course after dechlorination if necessary*
	Filter backwash water	*Media fines*	*Settlement and discharge to nearby water course*
During normal operation	*Clarification sludge*	*Regular batch discharges*	*Sludge to be dewatered through plate pressing (described above), and disposal to landfill*
	Filter backwash water	*Regular batch discharges;*	*Recycle*

		typically 300 mg/l solids content	
	Washwater from the sand filter	*Biological matter, such as algae*	*To settlement tank, drying and disposal*
	Treatment process overflows	*Could contain low residual chlorine and suspended solids*	*Discharge to nearby water course after dechlorination (as needed)*
	Chemical wastes	*Dross, flushings, drainage washings, spillages*	*Neutralize and hold for tanker removal*

172. The WTP construction will require permanent relocation of some dwellings, structures and gravesites currently found inside the designated site, as shown in Figure 11. Owners of the paddy fields inside the area will also be compensated. Gravesites will be relocated.

Figure 11. Marked areas showing dwellings and structures to be relocated at the WTP site

173. Based on the social and resettlement studies conducted under the project feasibility study, 32 households inside the boundary of the treatment plant site will need to be relocated subject to compensation, and 26 households will also be compensated for loss of their farming areas. Compensation as used here refers generally to a social support package which combines cash and training (such as for changing livelihood away from farming). The estimated cost of the compensation package for affected households and farmers in the WTP site is 12,256 million Dong ($660,000).

174. The detailed assessment of the resettlement aspect the water treatment plant site is presented in a separate report (Appendix 16 of the Draft Final Report).

175. The operation of the new water supply treatment plant will supply an additional 240,000 m^3/day developed over two phases beginning 2013. The additional supply will increase the volume of municipal wastewater generated. Currently, wastewater collection and treatment in the city is performed by a separate company, DURENCO, which operates four wastewater treatment plants and plans to extend coverage to meet the 70% national standard.

176. In anticipation of increased wastewater production, the city has planned for the simultaneous refurbishment and expansion of its wastewater treatment facilities—including the upgrading of the existing WWTPs at Phu Loc and Son Tra, and the construction of a new secondary WWTP in Hoa Xuan. These facilities are being designed to meet WWTP effluent standards for B-class receiving streams (specifically TCVN 7222:2002 on environmental regulations for the construction and operation of municipal WWTPs, and TCVN 188:1996 on discharge standards for urban WWTPs).

177. More water flowing into the distribution system could increase water losses through old and leaking pipes. Currently, with assistance from the Utility Support Project (USP) which is funded by the Netherlands Government, DAWACO is implementing a program aimed at reducing water losses, i.e., non-revenue water (NRW) in the distribution system, An important part of the NRW reduction program is detection and replacement of old leaking pipelines. Since the USP does not have a budget for pipeline replacement, the cost is planned to be included in the ADB investment program.

178. Ongoing interventions to reduce water losses have already brought about a reduction in non-revenue water from 38% in 2005, 35% in 2008, and 32% in June 2009--with the target set at reaching 20% by year 2020. A district metering program has been initiated and is at present being run as a pilot program in two district metering areas. Eventually the entire distribution network will be covered, with 80 district metering areas grouped into 25 caretaker monitoring areas, each having 5,000 and 7000 customer connection.

VI. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

179. With support from the Environmental Protection Research Center of the University of Danang, public information and consultation activities were carried out as part of a baseline survey of local environmental conditions along the pipeline corridor and in the WTP plant site. The interviews conducted using a questionnaire survey also assessed the community's perceptions and concerns about the proposed project.

Figure 12. Interviews with Local Residents

180. The 7-person survey team conducted the survey and interviews with local residents between January 15 and March 3, 2010. Table 6 shows the number of local residents interviewed (consisting of 55 households along the Cu De River, and 45 households near the pipeline route and WTP site). Eight community leaders were interviewed in greater depth for their views and concerns regarding the potential effects of the project on the community.

Table 10. Local Residents Interviewed

Location	Area Characteristics	Households Interviewed
Quang Nam 1 and Quang Nam 3 Hamlets, Hoa Lien Commune	Households inside or adjacent to the proposed WTP site	26
Quang Nam 3, Hoa Lien Commune	Households located along the raw water pipeline route	14
Quang Nam 1 and Quang Nam 3, Hoa Lien Commune	Vendors and stall owners along the provincial road adjacent to the public market	5
Quang Nam 3, Hoa Lien Commune	Fishing and shrimp-farming community along the Cu De River	15
Gian Bi, Na My, and Pho Nam Hamlets, Hoa Bac Commune	Households living near the Cu De River	30
Cells 7 and 11, Hoa Hiep Nam Ward	Households living near the Cu De estuary	10

181. Residents responding to the survey questionnaire were informed of its purpose and expected benefits, and the nature of construction activities to be undertaken in the area. Overall, there was no opposition raised against the proposed project. However, respondents and focus group discussants raised concerns that were mostly about: (a) traffic congestion during construction, given the narrow width of the road and alleys in the area, especially in Hoa Lien where there are schools and where a public market is located; (b) potential safety hazards due to speeding trucks and unfenced excavation pits, especially to children and the elderly; (c) dust, vehicle exhaust smoke, noise, and soil spilled on the road during transport of pipeline excavation materials; (d) wastes from construction and clogging of drains; and (d) influx of migrant workers and possible undesirable behavior such as gambling and trouble-making.

182. Table 11 gives a summary of the perceptions among local residents as to the potential effect of the project on their livelihoods, usual household activities, and living routines.

Table11. Local Perception of Seriousness of Project Impacts

Activity Affected	Percent of 55 Respondents along the Cu De River			Percent of 45 Respondents near Pipeline Route and WTP site		
	Serious Adverse Effect	Moderate Effect	Low or None	Serious Adverse Effect	Moderate Effect	Low or None
Farming, fishing or forest resource exploitation	0	4	96	7	15	78

Activity Affected	Percent of 55 Respondents along the Cu De River			Percent of 45 Respondents near Pipeline Route and WTP site		
	Serious Adverse Effect	Moderate Effect	Low or None	Serious Adverse Effect	Moderate Effect	Low or None
Trading and business activities (including aquaculture)	2	4	94	11	18	71
Cooking, drinking and washing	0	0	100	13	20	67
Living habits	0	0	100	18	29	53
Entertainment	0	0	100	0	13	87

VII. GRIEVANCE REDRESS MECHANISM

183. The mechanism described below follows the procedure adopted also for raising and resolving grievance related to community dislocation and resettlement impacts of the Project. As a guiding principle, grievances related to any aspect of the Project will be handled through negotiation aimed at achieving consensus. Complaints and grievances will pass through three stages before they can be elevated to a court of law as a last resort. DAWACO will shoulder all administrative and legal fees that might be incurred in the resolution of such grievances and complaints.

184. The first stage venue for raising and resolving complaints and grievances is the Commune People's Committee (CPC). An aggrieved party may bring its complaint or petition before any member of the Commune People's Committee, either through the village chief or directly to the CPC, in writing or verbally. Grievances may also be raised during follow-up consultations and interviews with local residents during construction. It is incumbent upon said member of CPC or the village chief to notify the CPC about the complaint. The CPC will then meet personally with the complainant and will have 15 days after the lodging of the complaint to resolve the complaint. The committee may obtain the assistance of the DONRE's Environmental Protection Center in evaluating the technical basis of complaints related to environmental impacts. The CPC secretariat will be responsible for documenting and keeping a record of all complaints that are lodged with the committee.

185. If not resolved in the first stage above, the second venue for grievances is the District People's Committee (DPC). That is, if after 15 days the aggrieved party or complainant does not hear from the CPC, or if the complainant is not satisfied with the decision taken on the complaint, the affected party may bring the case, either in writing or verbally, to any member of the DPC or the District CRC. The DPC in turn will have 15 days following the lodging of the complaint to resolve the case. The DPC secretariat is responsible for documenting and keeping a record of all complaints that are lodged with the district committee.

186. The third stage is the Provincial People's Committee (PPC). If after 15 days the aggrieved affected party does not hear from the District People's Committee, or if the complainant is not satisfied with the decision taken with regard to the complaint, the case may then be brought, either in writing or verbally, to any member of the PPC or the Provincial CRC. The PPC has 15 days within

which to resolve the complaint to the satisfaction of the concerned parties. The PPC secretariat is responsible for documenting and keeping a record of all complaints lodged with the committee.

187. In the event that the grievance remains unresolved even after being raised at the level of the Provincial People's Committee, the final resort is the Court of Law Arbitrates. Specifically, if after 15 days following the lodging of the complaint with the PPC, the aggrieved party does not hear from the Provincial CRC, or if the complainant is not satisfied with the decision taken on the complaint, the case may then be brought to a court of law for adjudication.

VIII. ENVIRONMENTAL MANAGEMENT PLAN

188. The environmental impacts and mitigation measures for the proposed project were described in Section V above. This section summarizes the significant impacts and mitigation measures with attention to key items to be monitored, the implementation set-up and assignment of responsibility, and the required budget.

A. Institutional Arrangement

189. The project will be implemented under the Da Nang People's Committee as the Executing Agency and the DAWACO as the project implementing agency. A Project Management Board (PMB) has been created to supervise the implementation, on behalf of DAWACO, of the capital investments related to the water supply project. The creation of the PMB follows Decision 53/2008/QD-UBND issued on December 2008 by the DNPC on the management of official development assistance (ODA) funds. Circular 03/2007/TT-BKH issued in March 2007 provides guidelines on the organizational structure and function of the PMB.

190. The DAWACO PMB has two operating groups: one for technical and administration matters, and another for planning and finance. The technical and administration group will be responsible for the detailed engineering and preparation of construction plans, and for construction monitoring. The planning and finance group will be responsible for overseeing the overall procurement process (starting from preparation of bid documents for specific works, to bid evaluations and recommendation of award, and up to payment for completed works) as well as for the overall financial monitoring of the project. Currently, there are 11 persons assigned to the PMB.

191. The PMB will be responsible for fulfilling the environmental requirements of the project, in particular for incorporating the mitigation measures and safeguards identified in this report in the detailed engineering design of the pipeline, WTP and distribution network, as well as in the bid documents and construction contract documents. The PMB will also be responsible for commissioning water and air quality sampling activities, undertaking environment-related investigations that may arise during implementation (in coordination with the DONRE Environment Protection Center), and responding to environment or nuisance-related complaints from residents or businesses affected by the project works.

192. The Environmental Protection Research Center (EPRC) of the University of Danang will be tapped to provide environmental monitoring support during project construction, using as baseline the environment survey that was conducted as part of this IEE. The Center will undertake sampling

and testing of surface water, groundwater and ambient air quality along the pipeline construction corridor three times per year during the two-year construction period. The EPRC will also conduct follow-up consultations and interviews with local residents to identify concerns or grievances arising during construction. The EPRC will report it findings to DAWACO, and the latter will relay the findings to the DNPC and DONRE.

193. A sub-group under the PMB would be designated to handle environment and public safety concerns. Its main duties are to:

- Oversee the implementation of the safeguards related to handling of spoils, water quality protection, public nuisance impacts, unexploded ordnance survey, and public safety;
- Coordinate with the DONRE Environment Protection Center on regulatory compliance issues (for water quality in streams affected by construction drainage or erosion from storage areas for excavated soil, noise and vibration from construction sites, sanitation in workers campsite, etc);
- Check that the safeguards are adequately addressed in the bidding documents (instruction to bidders), and in the evaluation criteria for awarding contracts;
- Prepare terms of reference for the survey of the pipeline route to detect unexploded ordnance, and ordnance disposal if found;
- Prepare TOR for the conduct of water and air quality sampling, including follow-up interviews with local residents on issues and concerns arising during project construction;
- Advise the PMB director on environment-related concerns arising during project construction, and recommend corrective measures;
- Disseminate to stakeholders the results of environment quality monitoring and implementation of safeguards, especially among households or small businesses near the construction sites;
- Prepare a quarterly status reports on environment and public safety protection to be submitted (through the PMB director) to the DNPC and DONRE.

194. Safeguards compliance monitoring during the construction phase—particularly compliance with safeguard measures specified in construction contracts, as recommended in this report--will be incorporated in the duties of the construction supervision company to be engaged by DAWACO (and supervised by the PMB). The compliance inspections and audits will be documented, and findings and recommendations for corrective measures submitted to DAWACO. During the operation phase, DAWACO will be responsible for safeguards and effluent monitoring, and the findings will be reported to the DONRE.

195. The DONRE Environment Protection Center will conduct random environmental monitoring and inspection before, during, and after construction, as well as in the event of emergencies. It will also review the monitoring reports of the EPRC. If abnormalities are found, the DONRE may impose fines and issue a notice of rectification with a specific deadline to the responsible entities. If complaints are formally received from the public through the People's Committee, the DONRE

Environmental Protection Center will carry out verification inspections, as described in the grievance redress mechanism.

196. Within three months after the construction completion or no later than one year, an environmental acceptance monitoring and audit report on the completion of the project components will be prepared by a qualified environmental institute, e.g., Environmental Protection Research Center of the University of Danang. The report will be reviewed and approved by the DONRE and submitted to ADB.

197. The environmental monitoring, including the environmental benefit monitoring, will be incorporated into the project performance management system (PPMS) indicators for the project. Assisted by a local environment specialist, the PMB will be responsible for analyzing and consolidating the data via their management information system. The PPMS will be designed to allow adequate flexibility to adopt remedial actions regarding the project design, schedules, activities, and development impact. At the start of the project, the PMB and consultants will develop comprehensive PPMS procedures for systematically generating the data on inputs and outputs of the project components, and agree on the environmental and related socioeconomic indicators to be used to measure the project impacts. The PMB will refine the PPMS framework, confirm the achievable goals, firm up the monitoring and recording arrangements, and establish the systems and procedures no later than 6 months after the loan takes effect.

B. Impacts and Mitigation/Safeguard Measures to be Monitored

198. The monitoring specifications described in Table 12 focuses on the potentially adverse environment-related impacts, based on the assessment presented in Chapter V. Benefits associated with providing adequate and safe water supply will be monitored within the project's overall design framework (i.e., the project logical framework).

Table 12. Monitoring of Significant Impacts and Mitigation Measures

Potentially Significant Impacts of the Project	Summary of Mitigation Measures and Safeguards	Verification and Monitoring Means
Construction: Excavation work for the pipeline trenches will produce spoil; heaps of excavated soil beside the trench could obstruct community access, and erosion from spoil storage areas could silt up nearby streams and drains. Dry heaps could cause dust nuisance.	*Temporary heaps of excavated soil to be used to backfill the pipeline trench should not be left on the roadside for long periods, and should be watered regularly to prevent excessive dust.* *At excavation sites close to drains pr streams, silt traps should be used to prevent excessive water turbidity.* *Storage or disposal areas for excess spoil should be sited so as not to be susceptible to flooding, and not located on steep slopes. Adequate drains/ditches should be installed around the area.* *Tender documents for construction should require provisions for proper handling and disposal of spoil. Soundness of measures should be part*	*Water quality along the Cu De River (at three locations) adjoining the 16 km pipeline route to be monitored every 3 months throughout the duration of pipeline construction. Include 16 criteria parameters under National technical standard QCVN 08:2008/BTNMT for surface waters.* *Groundwater quality to be monitored in three locations 2 times per year during project construction: 26 parameters based on Vietnamese Standard QCVN 09:2008 for underground water.* *Bidding documents, contractor plans and compliance reports on the temporary storage and disposal*

Potentially Significant Impacts of the Project	Summary of Mitigation Measures and Safeguards	Verification and Monitoring Means
	of selection criteria for contract awards.	*of spoils.* *Criteria used by the PMB procurement committee in contractor selection.* *Follow-up consultations and interviews with local residents, every 3 months during construction. (To be done after results of water and air sampling are completed.)*
Construction: Obstruction to traffic flow during raw water pipeline construction, exacerbated by the narrow road and work spaces: • *Local residents could be cut off from the road due to the trench-building* • *Increased traffic of dump trucks carrying spoils to and from storage areas* • *Air pollution from excavation and transport equipment* • *Traffic hazard to pedestrians, especially school children and elderly*	*Excavation and transport equipment should be appropriately sized to fit the narrow road and limited work spaces. Impose speed limits.* *Durable wooden or steel plates/planks should be placed across open trenches and drainage ditches to provide temporary crossings.* *Check emissions from construction and transport equipment for compliance with standards, particularly for particulates.* *During dry weather, the construction transport route near residential areas should be sprayed with water to prevent excessive dust. Dump trucks loaded with dry earth should be covered.*	*Air quality to be monitored in 3 locations and every 3 months along the pipeline construction route during construction; include 7 parameters based on Vietnamese Standard TCVN 5937:2005 for air quality.* *Bidding documents, contractor plans, and regulatory compliance reports.* *Criteria used by the PMB procurement committee in contractor selection.* *Follow-up consultations and interviews with local residents, every 3 months during construction.*
Construction: Nuisance and public safety hazards caused by pipeline excavation and pipe-laying activities in urban areas	Work schedules should be well-planned and activities during rush hours near schools and markets should be minimized; construction and materials storage sites should be adequately lighted at night; open trenches must be fenced and clearly marked; and adequate sanitation facilities for workers should be provided at the major work sites. Contractors must avoid activities producing loud noise and vibration if night time construction work is necessary. Ensure compliance with existing Vietnamese regulations and standards for managing pollution, nuisance effects, and public safety hazards related to construction works. Tender documents to require contractor to specify safeguards and compliance measures, which will be considered in	Bidding documents, contractor plans, and regulatory compliance reports. Criteria used by the PMB procurement committee in contractor selection. Follow-up consultations and interviews with local residents, every 3 months during construction.

Potentially Significant Impacts of the Project	Summary of Mitigation Measures and Safeguards	Verification and Monitoring Means
	awarding contracts.	
Construction: Accidental detonation of unexploded ordnance (UXO) during pipeline excavations	Ensure that the 16 km pipeline excavation corridor is surveyed for unexploded ordnance prior to construction work.	PMB will supervise the UXO survey and, if ordnance is detected, will be responsible for commissioning subsequent clearing work prior to construction.
Operation: Hazard posed by water treatment process chemicals during operation, of which Chlorine is the most hazardous	*Clearly mark the chlorine storage house, storage containers, and associated process equipment, and keep Chlorine containers moisture-free and stored separately from other chemicals.* *Provide adequate personal protective equipment for workers handling chlorine. They should be trained on safe work practices and emergency steps in case of exposure. Adopt regular inspection and maintenance schedule for all chlorine storage and handling equipment.*	*Detailed design of the water treatment plant facilities, and operating rules for the handling of chemicals during commissioning and WTP operation.*
Operation: Disposal of water treatment sludge and wastes from WTP operation	*The recommended design feature of the WTP is dewatering of sludge by plate pressing (producing caked sludge) so that it can be easily transported and disposed in controlled landfill.* *Proper procedures (during plant commissioning) for the disposal of test water, water used for disinfecting tanks, and other chemical wastes from the plant start-up and adjustment process will be incorporated into the contract specifications for the testing and commissioning stage of the WTP.*	*Detailed design of the water treatment facilities, construction plan, commissioning plan and report.*
Operation: Increase in the volume of municipal wastewater generated.	*The city has planned for the simultaneous refurbishment and expansion of its wastewater treatment facilities—including the upgrading of the existing facilities at Phu Loc and Son Tra, and the construction of a new secondary facility in Hoa Xuan. These facilities are being designed to meet WWTP effluent standards for B-class receiving streams.*	*Regular monitoring reports on wastewater treatment effluent with reference to standards set under TCVN 7222:2002 for the operation of municipal WWTPs, and TCVN 188:1996 on discharge standards for urban WWTPs.*

C. Budget

199. The monitoring budget summarized below covers: (a) follow-up perception surveys and consultations with local residents to be commissioned by the PMB, preferably with the Environmental Protection Research Center of the University of Da Nang which conducted the baseline environment/site survey and facilitated the public consultations for the IEE; (b) surface

water, groundwater and air quality monitoring during construction; (c) survey of the pipeline trench route to check that there are no unexploded ordnance that might endanger construction workers; (d) a local environment specialist to provide intermittent support to the PMB (in preparing survey TORs, assessment of water and air quality sampling results, drafting of safeguard provisions to be incorporated in construction tender documents and contracts, preparing reports to the DNPC and DONRE); and (e) cost of orientation-training for PMB staff and community leaders on managing environmental impacts of pipeline construction and related safeguards (to be facilitated by the environment specialist).

200. During the operation of the new water treatment plant, water quality monitoring of drinking water taps at various locations in the new or expanded DAWACO service areas will be done routinely by the Environment Protection Agency of the DONRE in compliance with Vietnam regulations (with reference to quality standards for drinking water under TCXDVN 33:2008/BXD) and using the agency's own budget.

Table 13. Budget for EMP and Monitoring

Item or Activity	Frequency	Budget (US$)	Source of Budget
Construction safeguards (as specified in Table 12)	Throughout construction period, including the commissioning of the WTP	To be incorporated in implementation contracts	Loan proceeds
Sampling and testing of surface water, groundwater and ambient air quality along the pipeline construction corridor	*3 times per year during the 2-year construction period*	*20,000*	*Loan proceeds*
Perception survey and follow-up consultations with local residents	3 times per year during construction	15,000	Loan proceeds
Survey of pipeline corridor for unexploded ordnance	*Once, prior to start of construction*	*100,000*	*Loan proceeds*
Local environment specialist	Intermittent input: 8 person-months over 2 years	32,000	Loan proceeds
Training and orientation for PMB and community leaders	Once, prior to start of construction	4,000	Loan proceeds
Environmental audit	Once, after project completion	30,000	Loan proceeds
Contingency (in case of construction delay)		29,000	Loan proceeds
	Total	230,000	

IX. CONCLUSION AND RECOMMENDATION

201. The proposed project will produce significant benefits for the population of Da Nang, specifically by enabling households that are currently not served or only partially served by DAWACO to shift from reliance on wells as a source of water (which has to be boiled or filtered) to more secure and safe piped water source.

202. The potential adverse environmental impacts of the project are the consequence mainly of construction activities, in particular the potential impairment of water and air quality in areas near

the pipeline construction corridor, and nuisance and safety hazards posed to nearby households and small businesses. However, these impacts are temporary and can be mitigated.

203. Project construction will not have a significant impact on the flora and fauna, as the pipeline and WTP construction works will take place in existing agricultural and settlement/urban areas. No historical relics will be demolished or relocated by the pipeline and WTP construction.

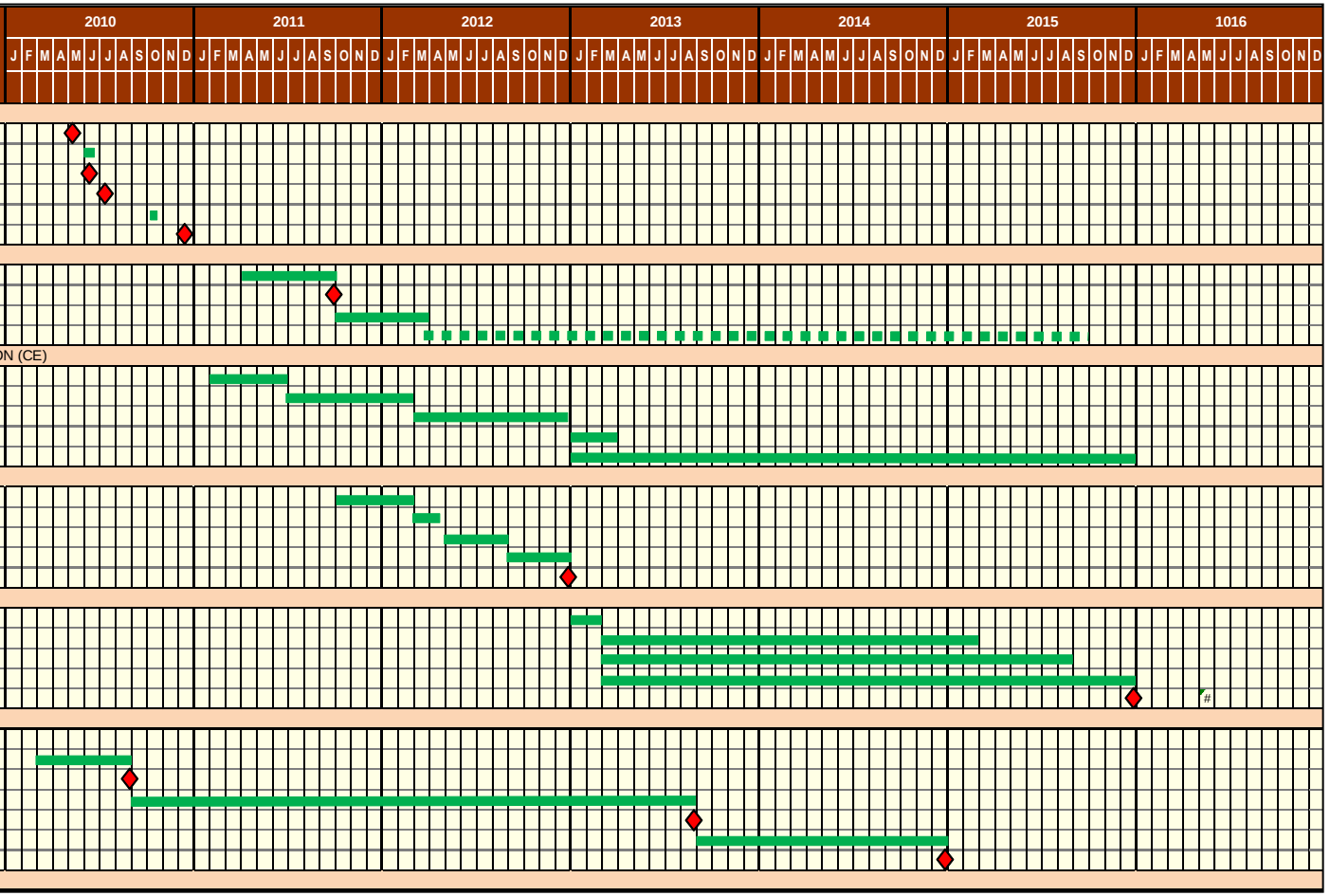
204. Potential adverse effects of sludge production during project operation have been avoided by incorporating sludge dewatering in the design of the water treatment plant.

205. Households that will be affected by construction activities, either because of dislocation or damage to property, will be relocated and/or compensated in accordance with ADB guidelines. These measures are presented in a separate report focused on the project's resettlement and compensation aspects, i.e., Appendix 16 of the Draft Final Report.

206. For purposes of compliance with ADB environmental assessment guidelines, no additional study or full environmental impact assessment is needed to further assess the potential environment impacts of the project.

Annex 1. Project Implementation Timetable

NO.	ACTIVITY	Date
	LOAN PROCESSING	
a.	BVI Issues Draft Feasibility Study	06/05/10
b.	ADB Loan Fact Finding Mission	
c.	BVI Issues Final Feasibility Study	12/06/10
d.	Da Nang PC Approves Final Feasibility Study	10/07/10
e.	Loan Negotiations	
f.	Board Approval of Loan	06/12/10
	IMPLEMENTATION OF ISP	
a.	Procurement of TA Consultants	
b.	Signing of TA Contract	30/09/11
c.	Prepare Training Programs	
d.	Implement Training	
	DETAILED DESIGN (DD) AND CONSTRUCTION SUPERVISION (CE)	
a.	Procurement of Consultants for DD and CE	
b.	Preparation of Detailed Design and Bidding Documents	
c.	Provision of Support to PMU for the bidding Process	
d.	Preparation of Sustainable Management Plan	
e.	Construction Supervision	
	PROCUREMENT OF CIVIL WORKS CONTRACTOR	
a.	Prequalification for Civil Works Contractors	
b.	Tendering	
c.	Tender Evaluation	
d.	Contract Procedures	
e	Signing of Civil Works Contract	30/04/12
	CONSTRUCTION PERIOD	
	Mobilisation	
	Construction of Raw Water Pipeline	
	Construction of Water Treatment Plant	
	Rehabilitation and Expansion of the Network	
	Hand over of Hoa Lien WTP Works	31/12/15
	SONG BAC DAM PROJECT	
	Agreement between DNPC and GERUCO	
	Tendering for Civil Works Contractors	
	Award of Contract	31/08/10
	Construction of Song Bac 2 Dam	
	Start of Impounding	31/08/14
	Dam Fills	
	Water available for Hoa Lien WTP	31/12/15



Annex 2. Surface Water Quality Sampling Results for July 2009

Parameter	Unit	Standard	River / Reservoir									
			Nam	Bac	Middle Cu De	Tidal Cu De	Cau Do	Yen	Tuy-Loan	Dong Nghe	Lo Dong	Hoa Trung
pH		6.0-8.5	6.74	6.80	6.70	7.65	7.60	6.89	6.54	6.22	6.67	6.71
DO	mg/l	≥ 5	6.8	6.8	6.5	3.8	6.0	6.0	6.0	6.8	6.82	6.85
TSS	mg/l	30	3.0	2.0	3.0	3.0	19	63	12	5	3	13
COD	mg/l	15	8	8	10	260	12	12	12	8	10	8
$BOD_5(20^{\circ}C)$	mg/l	6	2	2	4	68	4	6	4	2	4	4
N-NH	mg/l	0.2	0.04	0.02	0.06	0.12	0.16	0.18	0.18	0.06	0.10	0.12
Cl	mg/l	400	6	7	6	7100	20	18	18	10	10	8
F	mg/l	1.5	NF	0.16	NF	0.2	NF	NF	NF	0.16	NF	NF
N-NO-2	mg/l	0.02	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01
N-NO-3	mg/l	5	1.1	0.5	1.0	12	2.7	2.2	2.2	2.2	0.5	1.1
$P\text{-}PO^{-}_4$	mg/l	0.2	0.0	0.0	0.02	0.08	0.02	0.02	0.02	0.02	0.0	0.0
CN^{-}	mg/l	0.01	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
As	mg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Cd	mg/l	0.05	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Pb	mg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Crom III	mg/l	0.1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Crom VI	mg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Cu	mg/l	0.2	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Zn	mg/l	1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Ni	mg/l	0.1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Fe	mg/l	1	0.05	0.05	0.15	0.20	0.76	0.15	0.15	0.10	0.05	0.2
Hg	mg/l	0.001	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Detergents	mg/l	0.2	NF	NF	NF	0.18	0.18	NF	NF	NF	NF	NF
Oil&grease	mg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF

Parameter	Unit	Standard	River / Reservoir									
			Nam	Bac	Middle Cu De	Tidal Cu De	Cau Do	Yen	Tuy-Loan	Dong Nghe	Lo Dong	Hoa Trung
Phenol (total)	mg/l	0.005	0.14×10^{-3}	0.38×10^{-3}	0.45×10^{-3}	NF	0.15×10^{-3}	0.25×10^{-3}	0.58×10^{-3}	0.37×10^{-3}	0.19×10^{-3}	0.25×10^{-3}
Aldrin+Dieldrin	mg/l	0.004	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Endrin	µg/l	0.012	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
BHC	µg/l	0.1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
DDT	µg/l	0.002	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Endosunfan	µg/l	0.01	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Lindan	µg/l	0.35	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Chlordane	µg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Heptachlor	µg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Parathion	µg/l	0.2	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Malathion	µg/l	0.32	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
2,4D	µg/l	200	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
2,4,5T	µg/l	100	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Paraquat	µg/l	1200	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Total Radioactivity a	Bq/l	0.1	0.005 ± 0.001	0.0040 ± 0.001	0.0025 ± 0.001	0.0025 ± 0.005	NF	NF	NF	NF	NF	NF
Total Radioactivity β	Bq/l	1	0.006 ±0.005	0.055 ±0.005	0.0064 ±0.005	0.0064 ±0.007	NF	NF	NF	NF	NF	NF
E.Coli	MNP /100ml	50	7	7	7	NF	NF	NF	NF	NF	NF	NF
Coliform	MNP /100ml	5000	2.4×10^{2}	2.4×10^{2}	2.4×10^{2}	23	2.1×10^{2}	4.6×10^{2}	93	93	2.1×10^{2}	23

NF=Not Found

Annex 3. Surface Water Quality Sampling Results for November 2009

Parameter	Unit	Standard	River / Reservoir									
			Nam	Bac	Middle Cu De	Tidal Cu De	Cau Do	Yen	Tuy-Loan	Dong Nghe	Lo Dong	Hoa Trung
pH		6.0-8.5	6.32	6.53	6.46	6.54	6.57	6.45	6.31	6.20	6.20	6.32
DO	mg/l	≥ 5	6.2	6.2	6.0	5.0	5.6	5.8	5.8	6.2	6.20	6.0
TSS	mg/l	30	3.0	3.0	2.0	3.0	**57**	**86**	24	2	2	2
COD	mg/l	15	16	12	12	**60**	**40**	**42**	**20**	14	15	12
BOD5	mg/l	6	3.6	3.0	2.6	**10**	6	5	3.8	2.8	2.6	2.4
N-NH	mg/l	0.2	0.13	0.13	0.15	0.18	0.13	0.2	**0.30**	0.11	0.11	0.13
Cl	mg/l	400	8	8	20	**1400**	8	10	20	9	10	8
F	mg/l	1.5	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
$N\text{-}NO^-_2$	mg/l	0.02	0.01	0.01	0.01	**0.03**	0.01	0.01	0.01	0.01	0.01	0.01
$N\text{-}NO^-_3$	mg/l	5	1.2	1.2	1.4	3.1	2.2	2.2	2.2	0.9	1.0	1.0
P-PO-4	mg/l	0.2	0.01	0.01	0.02	0.06	0.05	0.05	0.06	0	0.0	0.0
CN^-	mg/l	0.01	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
As	mg/l	0.02	0.0022	0.0017	0.0019	0.0033	0.0030	0.0032	0.002	0.0017	0.0017	0.0016
Cd	mg/l	0.005	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Pb	mg/l	0.02	NF	0.0027	NF	0.0046	NF	0.0021	0.0021	NF	NF	NF
Crom III	mg/l	0.1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Crom VI	mg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Cu	mg/l	0.2	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Zn	mg/l	1	NF	0.014	NF	NF	NF	NF	0.014	NF	NF	NF
Ni	mg/l	0.1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Fe	mg/l	1	0.10	0.10	0.4	0.50	**0.15**	**1.20**	1.0	0.10	0.2	0.1
Hg	mg/l	0.001	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF

Parameter	Unit	Standard	River / Reservoir									
			Nam	Bac	Middle Cu De	Tidal Cu De	Cau Do	Yen	Tuy-Loan	Dong Nghe	Lo Dong	Hoa Trung
Detergents	mg/l	0.2	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Oil&grease	mg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Phenol (total)	mg/l	0.005	$0.3x10^{-3}$	$0.3\ x10^{-3}$	$0.17\ x10^{-3}$	$0.2\ x10^{-3}$	$0.2\ x10^{-3}$	$0.44x10^{-3}$	$0.16\ x10^{-3}$	$0.16\ x10^{-3}$	0.2x10-3	$0.2\ x10^{-3}$
Aldrin+Dieldrin	mg/l	0.004	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Endrin	µg/l	0.012	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
BHC	µg/l	0.1	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
DDT	µg/l	0.002	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Endosunfan	µg/l	0.01	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Lindan	µg/l	0.35	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Chlordane	µg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Heptachlor	µg/l	0.02	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Parathion	µg/l	0.2	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Malathion	µg/l	0.32	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
2,4D	µg/l	200	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
2,4,5T	µg/l	100	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Paraquat	µg/l	1200	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
Total Radioactivity a	Bq/l	0.1	0.0041 ± 0.001	0.0032 ± 0.001	0.0018 ± 0.001	NF	NF	NF	NF	NF	NF	NF
Total Radioactivity β	Bq/l	1	0.0050 ±0.005	0.0042 ± 0.005	0.0047 ±0.005	NF	NF	NF	NF	NF	NF	NF
E.Coli	MPN /100 ml	50	$9.3x10^{1}$	$2.1x10^{1}$	9	4	$1.1x10^{1}$	NF	$2.1x10^{1}$	NF	$2.1x10^{1}$	4
Coliform	MPN /100ml	5000	$2.4x10^{2}$	$4.6x10^{2}$	$4.3x10^{2}$	$9.3x10^{2}$	$4.6x10^{2}$	$4.6x10^{2}$	$1.1x10^{3}$	NF	$1.1x10^{3}$	$1.5x10^{1}$

NF=Not Found

Annex 4. Analysis of Drinking Water Samples from Present Water Supply Service Areas

Parameters	Unit	Standards	Location A		Location B		Location C		Location D		Location E	
			July 2009	Nov 2009	July 2009	Nov 2009	July 2009	Nov 2009	July 2009	Nov 2009	July 2009	Nov 2009
Conductivity	µS/cm		92	54	87	64	89	64	88	66	86	73
Turbidity	NTU	1.5	1.68	0.92	0.5	0.44	0.4	0.36	0.5	0.42	0.5	0.65
Color	Co	15	5	<5	5	<5	5	<5	5	<5	5	<5
Odor		0	0	0	0	0	0	0	0	0	0	0
pH		6.5-8.5	6.80	6.71	7.05	6.70	7.10	6.79	7.20	6.89	6.99	7.01
Total Hardness	$Mg/CaCO_3$	300	6	12	6	14	6	14	6	14	6	18
Consumed Oxygen	mg/l O_2	2	0.8	0.4	0.6	0.4	0.5	0.5	0.6	0.4	0.4	0.6
NH_3 -N	mg/l	1.5	0.01	0.02	0.04	0.02	0.06	0.02	0.05	0.02	0.02	0.02
NO_{2-}-N	mg/l	3	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NO_3 -N	mg/l	50	1.2	1.1	1.0	1.2	1.2	1.2	1.2	1.0	1.2	1.2
Cl^-	mg/l	250	12	14	10	12	12	12	10	16	10	12
SO_4^{2-}	mg/l	250	2	0	2	2	2	2	2	2	2	2
Mn	mg/l	0.5	0	0	0	0	0	0	0	0	0	0
Fe	mg/l	0.5	0	0	0	0	0	0	0	0	0	0
Coliform	MPN/100ml	0	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
E. Coli	MPN/100ml	0	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF

NF=Not Found