ASIAN DEVELOPMENT BANK

PPA: LAO 25179

PROJECT PERFORMANCE AUDIT REPORT

ON THE

NORTHERN PROVINCIAL TOWNS WATER SUPPLY AND SANITATION PROJECT
(Loan 1267-LAO[SF])

IN THE

LAO PEOPLE'S DEMOCRATIC REPUBLIC

December 2003

CURRENCY EQUIVALENTS

Currency Unit – kip (KN)

		At Appraisal (August 1993)	At Project Completion (June 1998)	At Operations Evaluation (March 2003)	(Average 2002)
KN1.00	=	$0.001394	$0.00029	$0.0000943	$0.0000993
$1.00	=	KN717	KN3,448	KN10,600	KN10,069

ABBREVIATIONS

ADB	–	Asian Development Bank
CAEP	–	community awareness and training education program
EIRR	–	economic internal rate of return
FIRR	–	financial internal rate of return
Lao PDR	–	Lao People's Democratic Republic
NPL	–	Nam Papa Lao
O&M	–	operation and maintenance
OED	–	Operations Evaluation Department
OEM	–	Operations Evaluation Mission
PCR	–	project completion report
PIO	–	project implementation office
PMU	–	project management unit
PPTA	–	project preparatory technical assistance
PWU	–	provincial water utility
PPAR	–	project performance audit report
RRP	–	report and recommendation of the President
SDR	–	special drawing rights
TA	–	technical assistance
WASA	–	Water Supply Authority
WTP	–	water treatment plant

WEIGHTS AND MEASURES

km	–	kilometer
lpcd	–	liter per capita per day
m^3/d	–	cubic meter per day

NOTES

(i) The fiscal year of the Government ends on 30 September.
(ii) In this report, "$" refers to US dollars.

Operations Evaluation Department, PE-632

CONTENTS

BASIC DATA
Loan 1267-LAO(SF): Northern Provincial Towns Water Supply and Sanitation Project

PROJECT PREPARATION/INSTITUTION BUILDING

TA No.	TA Name	Type	Person-Months	Amount ($)	Approval Date
1607	Northern Provincial Towns Water Supply Development	PPTA	21	420,000	19 Nov 1991
1987	Strengthening Planning Capabilities in Nam Papa Lao	ADTA	24	257,000	18 Nov 1993

KEY PROJECT DATA ($ million)	**As per ADB Loan Documents**	**Actual**
Total Project Cost	16.30	15.89
Foreign Exchange Cost	11.70	12.01
Local Currency Cost	4.60	3.88
Bank Loan Amount/Utilization[1]	13.00	12.65
Bank Loan Amount/Cancellation[2]		0.01

KEY DATES	**Expected**	**Actual**
Fact-Finding		20 Apr–4 May 1993
Appraisal		17–31 Aug 1993
Loan Negotiations		6–7 Oct 1993
Board Approval		18 Nov 1993
Loan Agreement		17 Feb 1994
Loan Effectiveness	18 May 1994	18 Jun 1994
Project Completion	31 Mar 1999	30 Jun 1998
Loan Closing	30 Sep 1999	5 Mar 1999
Months (effectiveness to completion)	58	48

ECONOMIC AND FINANCIAL INTERNAL RATES OF RETURN (%)	**Appraisal**	**PCR**	**PPAR**
Economic Internal Rate of Return	—	18.15	neg
Financial Internal Rate of Return			
Houayxay	2.66	7.20	neg
Pakxan	5.24	(0.03)	(1.20)
Phongsali	1.59	(1.20)	neg
Phonhong	5.39	neg	neg
Phonsavanh	5.57	3.30	7.10
Sayaburi	2.47	(3.20)	neg
Xam Nua	7.27	(1.90)	(0.20)

BORROWER Lao People's Democratic Republic

EXECUTING AGENCY Ministry of Communication, Transport, Posts, and Construction

---

— = not calculated, ADB = Asian Development Bank, ADTA = advisory technical assistance, neg = negative, PCR = project completion report, PPAR = project performance audit report, PPTA = project preparatory technical assistance, SDR = special drawing rights, TA = technical assistance.

[1] Equivalent to SDR9,165,000 at the time of approval and SDR9,159,267.59 at the time of loan closing.
[2] Equivalent to SDR5,732.41 at the time of cancellation.

MISSION DATA

Type of Mission	No. of Missions	No. of Person-Days
Fact-Finding	1	60
Appraisal	1	45
Project Administration		
Inception	1	28
Review[3]	7	112
Disbursement[3]	1	16
Special Project Administration[3]	2	16
Midterm Review[3]	1	16
Project Completion	1	26
Operations Evaluation[4]	1	22

[3] In conjunction with the review of other projects in the Lao People's Democratic Republic.
[4] The Operations Evaluation Mission comprised W. Kolkma (Evaluation Specialist/Mission Leader); K. Schonfeld (Staff Consultant); and N. Bouaphim (Assistant Project Analyst, Lao Resident Mission).

EXECUTIVE SUMMARY

In 1991, only about 33% of the urban population in the Lao People's Democratic Republic had access to treated water supplies. Reliable water supplies were available in only 7 out of 17 provincial capitals. No significant investment in urban water supply had been made since 1981.

The main objective of the Northern Provincial Towns Water Supply and Sanitation Project (Loan 1267-LAO[SF]) was to construct new water supply systems for seven towns—Houayxay, Pakxan, Phongsali, Phonhong, Phonsavanh, Sayaburi, and Xam Nua—to help the Government meet its water supply targets and thereby improve the population's health and support economic growth. The Project was to benefit some 76,000 town inhabitants. The Asian Development Bank (ADB) approved a loan of $13.0 million equivalent from the Asian Development Fund. The Government provided budgetary funds for the balance of the local currency costs. The actual project cost at completion amounted to $15.8 million, compared with an estimate of $16.3 million at appraisal. The lower actual cost of the Project was primarily due to the appropriate substitution of slow sand filters for the more expensive mechanical water treatment plants planned in four towns. The Project was expected to have been implemented over almost 5 years, from 1994 to 1998, with loan closing in 1999; however, due to the simpler designs the loan was closed 6 months early.

The Project was generally consistent with ADB's country operational strategy. Moreover, it had a poverty-reducing dimension, even though this was not an explicit intention of the country strategy. In terms of current ADB strategic priorities, the Project is relevant. The Project was also implemented generally satisfactorily and was completed 9 months ahead of schedule. The Project did, however, have several shortcomings. Although the many design changes led to improvements in four towns, in the other three they did not lead entirely to satisfactory outcomes. In Phongsali particularly, water from the spring source has to be pumped up an altitude of 600 meters, which makes high operational costs unavoidable. In Phonhong and Sayaburi, mechanical treatment plants were built. Slow sand filters, like those constructed in Houayxay, Phongsali, Phonsavanh, and Xam Nua, with the addition of presedimentation tanks, would have been more efficient and would have saved significant operational costs. Some other design flaws included overestimation of source potential in the dry season in a number of cases, insufficient staff training, and failure on the part of the consultants to provide operations manuals.

Operational performance was below potential. Even though all seven towns did produce and distribute water and service connections were installed on schedule, the water was not chlorinated adequately and not tested sufficiently frequently. The facilities' operation and maintenance left much to be desired, leading to inadequate water filtration, equipment breakdowns, and quicker than foreseen degradation of the assets.

Thus, the Project only partially achieved its main objective of providing potable water supplies to seven provincial towns. In total, the number of beneficiaries of the Project will be as intended in 2012: around 76,000, but the water is not bacteriologically safe, and people do not drink the water without boiling it. Given that the water still needs to be boiled before drinking, the Project's economic impact is limited. The overall economic internal rate of return is estimated as negative. Only in Houayxay was the threshold value of a 12% rate of return reached (at 16.1%), and only Pakxan and Phonsavanh had values above zero, at 10.5% and 1.7%, respectively.

The financial position of the water utilities in four of the project towns is precarious. Revenues are insufficient to cover operating expenses, depreciation, and interest payments,

and in 2002 most water utilities reported losses on their income statements. The lack of financial viability is already affecting the operation of the water supply systems through neglect of necessary maintenance. The water tariff in the project towns is not adjusted sufficiently to make up for inflation. As a result, the financial internal rate of return of the Project is negative, with a positive return achieved only in Phonsavanh.

The Project as a whole is rated partly successful, bordering on successful. It is assessed as relevant and efficacious, but inefficient and less likely to be sustainable, although with substantial institutional development and other impacts. Compared to a similar ADB-funded project in four southern provincial towns, completed and evaluated 2 years earlier, some good progress has been made in the sector. Unaccounted-for-water has remained within bounds, compared to many other towns in the region. Collection of water charges has been diligent, and overall financial management practices are improving. The decentralization of the water utilities in 1998 can also be assessed as positive, with the Water Supply Authority getting better at its role as regulatory body. Improving technical management and the institution of a regular water tariff adjustment mechanism are vital to the success of the utilities in the long term.

The evaluation highlighted several lessons. To begin with, the mode of water supply in developing countries should be carefully considered. Whereas many governments have decided to pipe potable water to every household to be used for all sorts of activities that do not require drinking water, another approach may sometimes be more appropriate. In poor countries like the Lao People's Democratic Republic, human resources and funds for adequate operation and maintenance are relatively scarce, and the culture is such that people tend to rely on drinking boiled water as tea rather than chlorinated water directly from the tap. In this context, making a relatively high investment in producing fully safe drinking water for a small population should be weighed against cheaper solutions that may rely on separate supply systems for nondrinking use and that produce modest amounts of safe water for distribution in tanks and bottles to a wider population.

Another lesson is to keep projects simple. In developing countries where technicians are scarce and where labor costs are low, designers of water supply facilities should focus on low mechanical content, an example of which is the slow sand filter.

Sustainability without financial viability should not be expected. An automatic tariff adjustment mechanism based on inflation along with more specific cost increases is essential for the financial sustainability of autonomous water utilities. The practice of requesting government subsidies to remedy cash flow shortages should be avoided.

Specific recommendations for improving the performance of the seven water utilities concentrate on using some additional investment to remedy the design flaws, producing site-specific operating manuals, applying disinfection methods for water more rigorously, and testing water quality. Once the water quality has improved and can be guaranteed, an education campaign should be launched to make drinking chlorinated water from the tap without boiling it first more acceptable. This could lead to annual savings of around $40 per household, equivalent to 2–3% of households' average annual income.


LAO PEOPLE'S DEMOCRATIC REPUBLIC
NORTHERN PROVINCIAL TOWNS
WATER SUPPLY AND SANITATION PROJECT
(as implemented)
PEOPLE'S REPUBLIC OF CHINA
MYANMAR
Mekong River
VIET NAM
Gulf of Tonkin
THAILAND
CAMBODIA
102°00'E
106°00'E
20°00'N
16°00'N
Phongsali
PHONGSALI
Louang Namtha
LOUANG NAMTHA
Xai
BOKEO
Houayxay
OUDOMXAI
LOUANG PHRABANG
Louang Phrabang
Xam Nua
HOUAPHANH
SAYABURI
Sayaburi
XIENG KHOUANG
Phonsavanh
VIENTIANE
SPECIAL REGION XAISOMBOUN
Xaisomboun
Phonhong
Pakxan
BORIKHAMXAI
VIENTIANE MUNICIPALITY
VIENTIANE
Thakhek
KHAMMOUAN
Savannakhet
SAVANNAKHET
SARAVANE
Saravane
SEKONG
Sekong
Pakse
CHAMPASSAK
Attapeu
ATTAPEU
N
0 50 100
Kilometers
Project Town
National Capital
Provincial Capital
National Road
Paved Provincial Road
River
Provincial Boundary
International Boundary
Boundaries are not necessarily authoritative.
03-2140 HR

I. BACKGROUND

A. Rationale

1. In 1991, about 33% of the urban population and 15% of the rural population in the Lao People's Democratic Republic (Lao PDR) had access to treated water supplies. Reliable water supplies were available in only 7 of the country's 17 provincial capitals. In those towns where water supplies were reliable, water supply was of acceptable quality in Vientiane and Savannakhet, but was poor in the other towns and did not meet the recommended World Health Organization standards. Water supply systems were generally old, in poor condition, and unable to provide for existing and future demand. Planning and skilled personnel to manage the systems were in short supply. The country had not made any significant investment in urban water supply since 1981. The need to further develop water supplies in the provincial capitals and strengthen the institutional capabilities of the national water supply agency was urgent.

B. Formulation

2. The Government recognized the deficiencies in the water supply systems and first requested a project funded by the Asian Development Bank (ADB) in southern Lao PDR to cover four provincial capitals. The first project started in early 1992 and was completed in 1998.[1] ADB supported a second water supply project, this time in Vientiane, a year later.[2] To address the water supply needs in northern Lao PDR, the Government asked ADB to provide project preparatory technical assistance (PPTA)[3] to carry out a feasibility study of water supply needs in seven provincial capitals: Houayxay, Pakxan, Phongsali, Phonhong, Phonsavanh, Sayaburi, and Xam Nua. The PPTA was completed in May 1993 and ADB's loan for SDR9.165 million was approved on 18 November 1993.[4] The loan became effective in June 1994.

3. The Project included advisory technical assistance (TA)[5] to help the national water supply corporation, Nam Papa Lao (NPL), and to follow-up on the earlier advisory TA recommendations.[6]

4. As other development partners also funded several water supply projects, the 1990s saw water supply investments in all of the Lao PDR's 17 provincial towns, with ADB being a leading source of funds in this sector.

C. Purpose and Outputs

5. The main purpose of the Project was to support the Government's goal of expanding sustainable water supply and sanitation coverage to its urban communities in a phased manner. The Project also included the following objectives: (i) to improve the physical well-being and health of the populations in the project towns through investments in sustainable water supply systems that provided safe, clean water in adequate quantities and at affordable prices; (ii) to

---

[1] Loan 1122-LAO(SF): *Southern Provincial Towns Water Supply Project,* for $9.6 million, approved on 19 November 1991. In 2000, the Operations Evaluation Department rated the Project partly successful.

[2] Loan 1190-LAO(SF): *Rehabilitation and Upgrading of Vientiane Water Supply Project,* for $9.5 million, approved on 17 November 1992, with cofinancing of about $20 million from the Japan International Cooperation Agency.

[3] TA 1607-LAO: *Northern Provincial Towns Water Supply Development,* for $420,000, approved on 19 November 1991.

[4] Loan 1267-LAO(SF): *Northern Provincial Towns Water Supply and Sanitation Project,* for $13 million, approved on 18 November 1993.

[5] TA 1987-LAO: *Strengthening Planning Capabilities in Nam Papa Lao,* for $257,000, approved on 18 November 1993.

[6] TA 1606-LAO: *Institutional Strengthening of the Water Supply Sector,* for $630,000, approved on 19 November 1991; and TA 1787-LAO: *Institutional Support to Nam Papa Lao,* for $210,000, approved on 17 November 1992.

improve the urban environment in the project towns by providing public sanitation infrastructure, including wastewater disposal and public toilet facilities; (iii) to foster community participation in sustaining and enhancing public utility services through a community awareness program; and (iv) to improve NPL's capacity to plan, design, construct, operate, and maintain water supply systems. Only two of the seven towns (Houayxay and Xam Nua) had water supply systems at the time, which were small and inadequate, and all the others relied on manual water collection from shallow wells, rivers, and springs, in some cases made easier by standpipes.

6. The Project had three component outputs: (i) Part A—developing water supply systems capable of delivering an average of 120 liters per capita per day (lpcd) of piped, treated water to, eventually, 76,000 town inhabitants;[7] (ii) Part B—undertaking environmental improvements, including providing improved sanitation facilities, 30 kilometers (km) of concrete-lined drainage channels, and one public toilet block in each town; and (iii) Part C—providing implementation assistance and institutional strengthening, including project management support, staff training, and a community awareness and training education program (CAEP).

7. The purpose of the advisory TA (footnote 5) was to (i) help NPL prepare a long-term, 7-year, rolling corporate plan; (ii) identify organizational changes that would improve planning capabilities; and (iii) prepare a national water supply and sanitation register.

D. Cost, Financing, and Executing Arrangements

8. The estimated total project cost at appraisal was $16.3 million equivalent, with a foreign exchange cost of $11.7 million. ADB's loan of $13.0 million was to be used to finance the entire foreign exchange cost, which included $1.3 million equivalent of the local currency costs and $1.65 million for consulting services. The Government would fund the remaining local currency costs of $3.3 million equivalent. ADB financing thus covered 80% of the total project costs (Appendix 1).

9. The loan was drawn from the Asian Development Fund to the Lao PDR under ADB's standard Asian Development Fund terms and re-lent from the Borrower as a subsidiary loan to its then main water supply organization, NPL, with provision for interest equal to ADB's ordinary capital resources (6.64% per year), a repayment period of 25 years, and a 5-year grace period, with the Government bearing the foreign exchange risk.

10. The Executing Agency for the Project was the Ministry of Communication, Transport, Posts, and Construction and the Implementing Agency was NPL. A project management unit (PMU), headed by a project manager, was to be established at NPL's offices in Vientiane to coordinate all project activities. A project implementation office (PIO) was also to be established at NPL's office in each town headed by a project implementation officer. The Project Implementation Coordination Committee, established under previous loans, was to convene meetings on a quarterly basis.

E. Completion and Self-Evaluation

11. ADB's project completion report (PCR) prepared in July 2000 discussed the Project's design, scope, implementation, and operational aspects. The preparation of the PCR followed a summary procedure that had a mandatory maximum main text of only eight pages. The PCR's

[7] The report and recommendation of the President (RRP) did not provide details about the length of pipe needed and the planned number of house connections. These are specified in the PPTA reports provided, and this project performance audit report (PPAR) uses the data in these reports.

rating of the Project was "generally successful."[8] This was based on the view that the Project was (i) highly relevant; (ii) efficacious as demonstrated by the early completion of work and satisfactory operation of the water supply systems; (iii) efficient due to an economic internal rate of return (EIRR) of 18.2%; and (iv) sustainable because of the use of simple, low-cost designs and NPL's commitment to continue to train and assist all provincial water utilities (PWUs). The PCR bestowed this rating despite the small amount of institutional development that occurred because of the shift of all of NPL's financial, operational, and maintenance responsibilities to the PWUs.

12. The PCR identified many changes in the design and anticipated that the Project would achieve a positive overall effect in terms of production capacity and number of users. It estimated that production capacity had risen from 17,856 cubic meters per day (m^3/d) at appraisal to 22,041 m^3/d and anticipated that the number of users would rise to 110,200 in 2012, compared with the 76,000 targeted at appraisal. The Operations Evaluation Department (OED) questioned the basis for the generally successful rating at the time and noted the need to review certain observations and estimates after a 3-year interval. The beneficiary estimate differed substantially from that in the consultants' PCR[9] (88,200). The PCR regarded all facilities as having been satisfactorily operated since their completion, but identified technical problems in Pakxan, Phongsali, and Xam Nua. The PCR considered that most of the environmental improvements proposed had not been implemented, but in retrospect regarded many of them as not cost-effective or as inappropriate. The PCR's positive economic reevaluation was based on, among other things, the assumptions that (i) between 60% and 80% of the water delivered was nonincremental supply replacing water drawn from wells or rivers; (ii) this water, rated at the economic cost of well or river water before the new system was in effect, increased by 10% in value annually; and (iii) the economic value of the incremental supply would increase to a similar degree. Despite these assumptions, the financial internal rates of return (FIRRs) calculated by the PCR were negative in five cases and were only positive in Houayxay and Phonsavanh. This evaluation presents an opportunity to look at these findings again, to update them, and to assess their effect on the Project's success rating.

13. According to the PCR, lessons learned included the need to (i) view the projected fluctuation in the value of the United States dollar to the special drawing rights as one factor in the computation of price contingencies, (ii) provide a line item in appraisal cost estimates for a project of this nature to cover the cost of a comprehensive program of test well drilling, and (iii) agree with the Executing Agency to require the first-ranked consulting firm to confirm the availability of key staff in writing prior to contract negotiations. If key staff are no longer available, the Executing Agency should then immediately seek ADB's concurrence to conduct contract negotiations with the second-ranked firm.

F. Operations Evaluation

14. This project performance audit report (PPAR) focuses on pertinent aspects of the Project's planning, implementation, outputs, outcomes, and impacts and presents the findings of the Operations Evaluation Mission (OEM) to the Lao PDR from 23 March to 11 April 2003. The OEM visited all seven towns in addition to Vientiane. Mission members inspected most of the water sources, treatment plants, and distribution systems and held detailed discussions with PWUs and previous project staff, as well as with the Water Supply Authority (WASA). The PPAR assesses the Project's relevance, efficacy, efficiency, sustainability, and institutional

[8] On a three-point scale of generally successful, partly successful, and unsuccessful.
[9] BETURE SETAME of France in association with SEATEC of Thailand and SK Consultant of Lao PDR. 1998. Northern Provincial Towns Water Supply and Sanitation Project, *Project Completion Report.* Vientiane.

development and other impacts. The Project's attached TA (footnote 5) was not evaluated, as it was already part of another evaluation.[10]

15. The PPAR is based on a review of the PPTA, the project document, the PCR, ADB files, observations in the field, a report by a consultant engaged by OED,[11] and discussions with and documents provided by the Borrower and the Executing Agency. Copies of the draft PPAR were provided to the Borrower and to pertinent ADB staff for review. Comments received were taken into consideration in finalizing this report.

II. PLANNING AND IMPLEMENTATION PERFORMANCE

A. Formulation and Design

16. The main thrust of ADB's country operational strategy in the Lao PDR is to help the Government with its transition to a market economy through policy reform to develop competitive markets and encourage private sector development, and through direct capital investments to support private sector activity. The Project was to a certain extent in line with this concept, but it did not incorporate measures to develop competitive markets in water supply or to encourage private sector participation in the provision of potable water.[12] The Project had a poverty-reducing dimension because of its implicit objective of supplying at least 40% of the poor in the seven towns with piped drinking water, even though poverty reduction was not an explicit intention of the country operational strategy. Alternatives to increase the Project's poverty reduction effects were, however, not worked out. The Project classification at approval was human resources development, with the environment as its secondary classification. In terms of current ADB strategic priorities, the Project is relevant.

17. The PPTA organized a good and detailed socioeconomic survey, but its hydrogeological study was much more limited, which is not surprising given the complete absence of data and the limited time spent collecting such data. The final report recommended test drilling and at least 1 year of water level monitoring in many places. In retrospect, the feasibility studies included too many erroneous assumptions. Demand for a wastewater drainage component of the Project was investigated in much less detail than the water supply component and the project consultant deemed the proposals to be only partly feasible. This contributed to NPL's reluctance to fully implement the component once the Project had started. For these reasons, the PPTA can be rated only partly successful.

18. The report and recommendation of the President (RRP) was based on the PPTA report with regard to cost estimates and intended beneficiaries, but did not present the predesign of the individual components. In addition, the RRP did not provide EIRR calculations, given in the PPTA report, and made no financial provision for a comprehensive program of test drilling. The Executing Agency approved the drilling program after a delay of 4.5 months and paid for it out of ADB's contingency provision. The predesign was based on a comprehensive, high-quality socioeconomic survey and on much less solid hydrogeological data. During detailed design, the predesign was changed in six of the seven towns. In Houayxay, the river source was changed to water abstraction from four natural spring sources. In Pakxan, the identified river source was changed to groundwater sources. In Phonhong, the groundwater source was converted to a

[10] ADB. 2003. *Technical Assistance Performance Audit Report on Selected Advisory Technical Assistance for Institutional Development and Capacity Building in the Water Supply and Sanitation Sector in the Lao People's Democratic Republic and the Socialist Republic of Viet Nam.* Manila.

[11] The field notes and detailed recommendations on the seven water utilities are available on request.

[12] This was not unlike the other water supply and sanitation projects that ADB was undertaking in the Lao PDR at the time (footnotes 1 and 2).

river source. In Phongsali, where the most drastic change was made, existing spring sources in and around the town, at an altitude of 1,400 meters, were changed to a natural spring source available some 600 meters lower and accessible only via a 6-km access road constructed for the purpose. This radical change led to a need for three diesel-powered pump stations and resulted in extremely high operating costs of the system. The reasons for this design change are not documented. In Phonsavanh, the identified water source was changed to four natural spring sources. Only in Sayaburi did the river source identified survive the detailed design phase. The changed designs in six towns also had implications for the treatment systems. The decision to construct more slow sand filters instead of relying fully on mechanical rapid sand filters as proposed in the PPTA was appropriate, and led to cost savings that in part were spent on laying much more pipe than foreseen. Appendix 2 presents an overview of the design changes. The OEM identified some design errors in the four slow sand filter systems. In Phonhong and Sayaburi, the mechanical treatment plants are unnecessarily complex and add to operating costs. Appendix 3 presents an overview of design flaws, but notes that experienced plant managers could reduce the negative effects of the flaws.

19. Both NPL and the consulted viewed most of the Project's sanitation component, that is, the inclusion of 30 km of wastewater drainage channels, as inappropriate and it was not implemented.

B. Achievement of Outputs

1. Component A: Development of Water Supply Systems

20. Water supply systems were developed as follows in each of the towns:

(i) **Houayxay.** Spring-fed raw water sources were developed; a new slow sand filter water treatment plant (WTP), and about 35.4 km of pipelines and storage tanks were constructed, and 788 metered house connections were installed.

(ii) **Pakxan.** Seven deep wells complete with submersible pumps, a pump control house with chlorination facilities, and about 48.2 km of pipelines and storage tanks were constructed and 1,140 metered house connections were installed.

(iii) **Phongsali.** Spring-fed raw water sources were developed. Three pump houses with duplex, diesel engine-driven, five-stage centrifugal pumps; a new slow sand filter WTP; and about 14.7 km of pipelines and storage tanks were constructed. A total of 594 metered house connections were installed.

(iv) **Phonhong.** A pontoon-based river intake pump station, a package rapid sand filter WTP, and about 23.6 km of pipelines and storage tanks, and installation of 807 metered house connections were installed.

(v) **Phonsavanh.** Spring-fed raw water sources were developed. A new slow sand filter WTP, and about 55.2 km of pipelines and storage tanks were constructed. A total of 1,866 metered house connections were installed.

(vi) **Sayaburi.** A pontoon-based river intake pump station, a package rapid sand filter WTP, a diesel engine generator set, and about 64.9 km of pipelines and storage tanks were constructed. A total of 1,058 metered house connections were installed.

(vii) **Xam Nua.** Spring-fed raw water sources were developed. A new slow sand filter WTP, and about 31.4 km of pipelines and storage tanks were constructed. A total of 865 metered house connections were installed.

21. Appendix 4 summarizes pertinent characteristics of the seven project towns in 1993 and the design capacity of the water supply systems. The RRP did not specify exact outputs and outcomes for the seven towns.

2. Component B: Environmental Improvements

22. The proposed construction of 30 km of concrete-lined channels for wastewater drainage was largely abandoned, and only some 3 km of drainage channels were constructed, mostly as part of the actual plants. This was allegedly due to lack of demand. The reasons the project consultant gave were (i) technical and practical difficulties involved in constructing the channels, (ii) evidence of many households having septic tanks with soakaways, (iii) Houayxay's preference not to include this in the loan, and (iv) shortage of available funds in places in which the redesign of the water supply system proved more costly than originally anticipated. The Project constructed 10 public toilet buildings in place of the 7 planned, but constructed only 1 public wash area compared with the 7 planned.

3. Component C: Implementation Assistance and Institutional Strengthening

23. The Project addressed the capacity of NPL, and later of the PWUs, to plan, design, construct, operate, and maintain water supply systems by (i) establishing a PMU and seven PIOs to support the Executing Agency in project implementation, and (ii) providing consulting services for detailed engineering design and construction supervision. Community participation in sustaining and enhancing public utility services was only marginally achieved. The CAEP, separately contracted to consultants, was supposed to provide information to the communities prior to implementation of the works on the benefits of an improved water supply and sanitation, the capital costs of the works, the tariff structure, the connection charges, the billing structure, the management of the system by NPL, and so on. Information about water chlorination and testing was not included. After implementation, the program was to be amended and continued. The CAEP was not effectively implemented because NPL lacked a good community development unit. The only town with an effective unit found by the OEM was Sayaburi. The other towns turned out to be only marginally interested in CAEP.

C. Cost and Scheduling

24. The actual project cost amounted to $15.89 million, 2.5% less than the appraisal estimate. The Project was completed in June 1998, 9 months ahead of schedule, while the loan closed almost 6 months early, in March 1999 instead of September 1999. The PCR attributes the cost underrun primarily to the depreciation of the kip against the dollar, which decreased the dollar cost of the local currency financing and the valuation in dollars of the cost incurred by the Government outside the loan. However, the costs of civil works, equipment, and materials increased.

25. Table 1 shows the major cost components that differed significantly from appraisal. While much more piping was installed than envisaged at appraisal, fewer house connections were installed. Constructing only 3.4 km of a planned 30 km of drainage channels estimated to cost about $1 million incurred savings of about $900,000, or 5.5% of the appraisal estimate.

Table 1: Summary of Main Changes in Appraised Versus Actual Project Costs

Item	At Appraisal	As Constructed	Impact
Pipelines (kilometer)	61.47	273.00	Significantly more expensive
Number of Connections	9,780	7,118	Significantly less expensive
Process Complexity	More complex	Less complex	Significantly less expensive
Channels (kilometer)	30.0	3.4	Significantly less expensive
Engineering ($ million)	1.65	1.83	More expensive

Source: ADB. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila.

26. Another significant cost difference resulted from using quite different process designs. At appraisal, the predesign called for one five-pump well supply, one rehabilitation, chlorination plus augmentation/WTP supply, and four river intakes (three via pontoons) and WTPs, or a total of six complex WTPs. As constructed, process facilities were one seven-pump well supply, two pontoon river intakes and complex WTPs, and four slow sand filter plants (two of which were 100% gravity plants).

27. The cost of international consulting services increased from $1.65 million to $1.83 million because of the addition of the test well drilling program and a 4-month extension.

D. Procurement and Construction

28. Procurement was carried out according to ADB's *Guidelines for Procurement*. A total of 14 packages—5 for civil works and 9 for supply contracts—was procured, amounting to $10.6 million. International and local competitive bidding was used for most of the contracts. Force accounts were used for spring abstraction headworks, service roads, and service connections. Six contracts were let for mechanical and electro-mechanical equipment and three contracts were let for civil works. In general, bid analyses were performed competently. The OEM found one instance where the outcome may have been different had the bid analysis been more thorough. For Contract SUP-01-E (treatment, mechanical, electro-mechanical equipment), the project consultant failed to adjust the evaluated prices of the first- and second-ranked bidders for the significantly different efficiencies of pumping equipment. All major contracts were accomplished essentially as scheduled. Appendix 5 summarizes the procurement schedule.

29. More than 30 lengths of ultraviolet (resistant) polyvinyl chloride pipe failed in Houayxay and Sayaburi in a peculiar manner after project completion (Appendix 6, Photo A6.1). One length broke prior to contract completion and was replaced. Reportedly, all failures were approximately straight splits along the pipes' obverts extending from bell to bell.[13] The semi-circumferential split was reportedly caused during the removal of the broken pipe rather than as part of the failure.[14] Concrete work was fair with the exception of Phongsali, where many cracks occurred. Office buildings and stores were well designed and reasonably well finished. Mechanical installations were generally adequate.[15]

[13] A bell is a wider pipe end.

[14] Staff of the water utility speculated that the cause was high pressure, because the failures occurred in the lowest part of the systems. Review of the plans indicated that the static head is about 50 meters, or five bar, which is believed to be a little more than half the design pressure rating of the pipe.

[15] In places, locally made fittings were used that have corroded prematurely (e.g., Phongsali pump houses [Appendix 6, Photo A6.2] and Phonhong and Sayaburi intake structures) or are of the wrong pressure rating (e.g., Pakxan control house pipe fittings). Flow meters were generally installed without the usual upstream and downstream straight pipe lengths required by the manufacturer to ensure meter accuracy.

E. Organization and Management

30. Organization and management were only partly consistent with agreed arrangements at appraisal. The Project provided for institutional support. Support was needed for the PMU and PIOs because of the relative inexperience of NPL personnel. The support pertained mainly to operations and had on-the-job training effects. Unfortunately, the PMU did not have a full-time deputy project manager as planned, whereas the PIOs have been weak since their establishment, 20 months late, in July 1996. The PMU appointed only one of the intended two project engineers, and he left in March 1997, since when the PMU has not had a project engineer. The PIOs had minimal input into the decision-making process and the PMU lacked the experience to make informed decisions. The Project Implementation Coordination Committee convened quarterly, but did not include a representative of the Ministry of Finance. As a result, the project implementation consultant, while overburdened, had a relatively free hand in making decisions about project design and other issues.

31. Consulting services were procured in accordance with ADB's *Guidelines on the Use of Consultants* and contracted to a consortium of two international engineering firms in association with a domestic firm. Consulting services were provided for engineering design and construction supervision. As discussed in the PCR, the consulting services contract was to provide 41 person-months of international consulting services and 88.5 person-months of domestic consulting services.[16] Because of delays in the project schedule, the contract was extended to add 4 person-months of domestic consulting services, but this extension was inadequate. Much of the design and supervision work depended on one engineer from an international consulting company who was hard pressed to provide a complete range of services, in part because at that time some towns such as Phongsali and Xam Nua were virtually inaccessible. The inexperience of the PIOs meant that more supervision resources were needed to implement the Project adequately. The international contractor's inexperience and unwillingness to follow instructions exacerbated the situation. The Project benefited from a benevolent consultant who stayed on the job longer than was paid for, but indications suggest that the Project was completed too early. The consultant did not produce project operating manuals, design briefs were not left behind by the consultant, and certain components appear to have been finished sloppily because the contractors were in a hurry and the consultants appear to have had insufficient time to complete adequate supervision.

32. The staff of PIOs included a unit head, a technical staff member, and a financial staff member. After decentralization (para. 33), the PIOs became PWUs. Currently, only a few staff of the former PIOs serve as senior management of the PWUs.[17]

33. In mid-1998, the Government unexpectedly decentralized the water sector to the provincial level. NPL's role became confined to servicing the Vientiane prefecture and training the staff of the newly autonomous PWUs in the operation and maintenance (O&M) of water supply facilities. The decentralization had little influence on implementation, because most of the construction components had already been finalized. ADB was, however, concerned about the continuation of training and the availability of sufficient tariffs for all PWUs to be able to carry

[16] ADB's similar sized Southern Provincial Towns Water Supply Project (footnote 1), executed 2 years earlier in four towns, had 67.5 months of international consultancy and 107.2 months of domestic consultancy.

[17] In Houayxay, senior staff included the former PIO technical representative; in Pakxan, the PWU included the former PIO technical and financial representatives and the former head of the PIO; in Phongsali, only one former PIO member was in a senior management position; in Phonhong, only the former PIO financial representative was on the PWU's staff; in Phonsavanh and Sayaburi, no former PIO members staffed the PWUs; and in Xam Nua, only the former head of the PIO worked for the PWU.

out viable O&M, now that cross-subsidies through NPL were no longer possible. WASA, created in mid-1999, has increasingly taken over the role of providing technical support to the PWUs.

III. ACHIEVEMENT OF PROJECT PURPOSE

A. Operational Performance

34. Operational performance is measured in terms of the Project's achievements in water production, coverage, and O&M.

1. Production and Coverage

35. According to the PCR, the aggregate production capacity in the seven project towns increased from 17,856 m^3/d at appraisal to 22,041 m^3/d.[18] The OEM estimates that the final figure will be closer to 17,000 m^3/d, given the experience with certain source limitations that have become apparent in recent years. In 2002, the PWUs jointly produced an average of 7,538 m^3/d. The Houayxay and Phonsavanh PWUs demonstrated the large variability of water supply over the years, with the Phonsavanh PWU claiming that climatic and environmental changes (hill erosion caused by excessive slashing and burning) had had a negative impact and significantly reduced capacity in comparison with the design. In Xam Nua, the use of water for irrigation during certain months reduced capacity. In Pakxan, only five of the seven wells were still functional. In Phonhong and Sayaburi, the river could provide limitless water, but it was sometimes too turbid for the package treatment plants.

36. Appendix 7 lists some pertinent information about production and coverage for the seven towns in 1999 and 2002. In terms of numbers of households connected, the targets set at appraisal have been more or less achieved. The target was to rise from 60% of households in the service areas at project completion to 80% of the growing population in these areas by 2012. In 1999, some 58% of the target had been achieved, and by the end 2002, the percentage was 61%. In terms of connections, more has been achieved than the target: 7,348 in 1998 instead of 6,720. However, the difference might be partly due to a number of connections to government users that were not included in the latter figure. If current expansion continues, the figure of 80% of the service areas may be achieved in 2012 despite the source problems. The Project's appraisal target of providing an average of 120 lpcd (equivalent to 9,120 m^3/d) ultimately to around 76,000 users can be readily achieved (in 2002, it was 88 lpcd for almost 59,000 users).[19] A particularly positive aspect is that six of the seven systems can provide water for 24 hours a day. This is convenient, and has the effect of reducing the chances of contamination of the water in the pipes. Government facilities, such as schools and hospitals, are also benefiting from the systems and consume around 15% of the water produced (20% was assumed). Of the water produced, 16% is reportedly unaccounted for (15% assumed), with the highest proportion being 24% in Phonsavanh. Theft is a relatively minor problem.

37. Water production and sales are better than expected at appraisal in three of the seven towns and not as good in four. Overall, sales are around 14% lower than originally expected for 2002. Table 2 lists the differences.

[18] The economic analysis in the PCR was, however, based on the more conservative estimate of 17,282 m^3/day, to be achieved in 2012 and maintained from then on.

[19] The feasibility study had assumed an average of 150 lpcd in most cases. The final production capacity achieved allowed a much higher average of 220 lpcd, given the target of providing 80% of the towns with piped water supply in 2012. This does not take nontechnical losses into account.

Table 2: Production Performance, 2002

Subproject	Water Produced (m^3)	Water Sold (m^3)	Nonrevenue Water (%)	Assumed Water Sales in 2002 at Appraisal (m^3)	Actual/ Assumed (%)
Houayxay	525,891	446,964	15	263,290	170
Pakxan	532,126	472,548	11	437,341	108
Phongsali	68,300	52,827	23	180,425	29
Phonhong	218,870	190,417	13	292,863	65
Phonsavanh	751,000	573,640	24	758,533	76
Sayaburi	313,913	267,795	15	491,314	55
Xam Nua	341,160	297,716	13	260,801	114
Total	**2,751,260**	**2,301,907**	**16**	**2,684,567**	**86**

m^3 = cubic meter.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; and ADB. 1993. *Technical Assistance to the Lao People's Democratic Republic for Northern Provincial Towns Water Supply Development.* Manila.

38. In 2002, the service areas covered almost 92% of the town areas, and the overall proportion of the population in town areas connected to piped water supply was around 56%. Given the increase in population in the peripheral areas, many PWUs' desire for further investment in water supply is understandable.

39. The OEM projects that with good management, the Project could benefit 77,300 consumers in the seven towns by the construction horizon year of 2012, with maximum consumption of 220 lpcd, although not in all towns in all seasons. This is similar to what was foreseen at appraisal, that is, 76,000 consumers with maximum consumption of 235 lpcd. Some PWUs have already opted to expand their networks on the basis of a more modest estimate of maximum water consumption per capita. In Houayxay, Phongsali, Phonsavanh, and Xam Nua, the spring sources are more limited than foreseen during the dry season. At the time of the OEM, 58,820 consumers and a further 367 government facilities were connected, and 10,238 water meters had been installed.

2. Operation and Maintenance

40. Even though all utilities are routinely producing and selling water, weaknesses are apparent in their O&M. First, PWU staff appear inadequately trained in relation to the technical demands of the three different processes (groundwater and well pumps, spring water and slow sand filtration, and river water and rapid sand filtration). Second, staff do not have O&M manuals in either Laotian or in English. This was an oversight by the Executing Agency, which did not insist on receiving these important documents from the consultant. The preparation of O&M manuals by the design consultant is not only usual practice, but this was a specific task identified in the terms of reference for the loan consultancy. Third, staff do not apply calcium hypochlorite solution in sufficient doses and with the frequency that would adequately disinfect (chlorinate) the entire water supply system.[20] In general, the staff also does not perform routine tests frequently enough—often less than once a month—and hardly ever sends samples to laboratories to provide a certain level of comfort with the results. Residual chlorine testing in the distribution system is inadequate in all cases. Despite the 24-hour supply in most towns, power outages or breakages pose a risk of contamination of water in pipes in some systems. Appendix

[20] Calcium hypochlorite solution facilities are not used effectively. PWU staff noted that they had changed the formulation of the solution, making it weaker by a factor of 2.5. In Phongsali, the facilities are not used at all.

6 summarizes the operational problems of the seven water utilities, which are partly relating to design flaws. Overall, O&M is inadequate.

B. Performance of the Operating Entity

41. All the PWUs have been producing annual financial statements since their formation in 1998. The OEM reviewed their financial performance with the assistance of water utility personnel.

42. In comparison with a similar project in southern Lao PDR evaluated 3 years ago,[21] financial management has improved. This can be largely attributed to the assistance provided by WASA in coordination with a number of external funding agencies, including ADB, the World Bank, the Norwegian Agency for Development Cooperation, the United Nations Development Programme, and the Japan International Cooperation Agency. All PWUs now have adequate numbers of staff, ranging between 16 and 26. Indeed, the number of staff currently employed (including contracted staff) is around 141, double the number foreseen by the RRP. Income statements and balance sheets are produced annually in the same format, except for Phongsali, which produces a less sophisticated annual report. Financial analysis can be based on these statements, with some queries remaining, mainly about the calculation of depreciation costs. These differ markedly between the water utilities, and are sometimes estimated following a provincial government's decision not to reflect full costs.[22] Tariff levels vary significantly between PWUs (Appendix 7), as does tariff structure, and are the subject of a current study by WASA. The PWUs have yet to establish a mechanism for regularly adjusting tariffs in line with inflation as stipulated in the ADB loan covenant, and increases have generally been overdue since 2001, but are difficult to enforce without approval by the provincial governors. For this reason, most PWUs did not foresee a tariff revision in the near future. Most PWUs were in a difficult, but not desperate, financial situation in 2002, except Phongsali, which is well known for being unable to cover costs, and which can therefore count on some government subsidy. Five of the seven PWUs had a positive cash flow; however, they generally devoted insufficient funds to O&M. The PWUs had not yet started repaying the loan principal, scheduled for 2002, but now shifted to 2003, to the Ministry of Finance. Thus, their financial situation will doubtless become more difficult in the coming years, with most PWUs having negative cash flows. Appendix 8 presents the income statements and balance sheets as submitted by WASA for 2002.[23]

43. The Loan Agreement for the Project contained a number of covenants,[24] some of which pertained to financial performance. In addition to the covenant on the tariff adjustment mechanism, several others were not fully complied with. The debt-equity ratio was not to be greater than 70:30, a target achieved by all the PWUs in 2002 except Houayxay and Phongsali (Appendix 8). Three towns could not comply with the debt-service covenant. This suggested that the debt-service coverage ratio should have been 1.2:1 or greater from 1996 on, but Houayxay, Phongsali, and Sayaburi were unable to cover their annual debt service. In the case of Houayxay, this was mainly because the PWU had not charged a tariff during the first year of operation. The PWUs' outstanding accounts at the end of the year were not to be greater than the value of 3 months of water sales. Although collection efficiency was good with respect to

[21] ADB. 2000. *Project Performance Audit Report on the Southern Provincial Towns Water Supply Project in the Lao People's Democratic Republic.* Manila. This project was rated partly successful.

[22] For instance, the Sayaburi PWU's income statement for 2002 includes a depreciation cost of KN16.6 million, whereas Phonhong, which has a similar plant, includes KN390.7 million.

[23] These are not always fully compatible with WASA's 2002 benefit monitoring and evaluation report or with information the OEM obtained from individual PWUs (e.g., on accounts receivable) that may be reflected in other appendixes.

[24] The list of covenants is shown in ADB. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila (Appendix 3). Available: http://www.adb.org/Documents/PCRs/LAO/pcr_lao25179.pdf

private consumers because of a strict disconnection policy, in at least two cases, public sector consumers have had large outstanding accounts beyond this threshold value. The OEM noted long outstanding dues of KN128.7 million in Phonhong, KN83.2 million in Phonsavanh, KN60.6 million in Sayaburi, and KN15.9 million in Phongsali. In Houayxay, the Government and the army owed KN56.2 million, but an additional KN89.2 million was still on the books for water distribution to private consumers in the first year, 1998, when no tariffs were collected.[25] Only two of the seven towns complied with a covenant on public toilets provided under the Project to be operated under private leasing arrangements, which led to small incomes in comparison with the investment made.

C. Financial and Economic Reevaluation

44. The appraisal estimates of the FIRRs were all positive, and varied from 1.6% for Phongsali to 7.3% in Xam Nua. They were calculated on the basis of socioeconomic surveys in all the towns. Willingness to pay was high, and at that time ranged from 4% to 6% of household income. In the PPAR, the FIRR was reevaluated based on the value of the revenues collected from water sales, new connections, and meter rental. A drainage surcharge was not applied in any of the towns. Appendix 9 provides the details of the financial analysis. Whereas in the PCR, two of the seven FIRRs were positive, the PPAR estimates one as positive: Phonsavanh (7.3%). The FIRR for the Project as a whole is negative.

45. The negative net present values are caused primarily by the insufficient water tariffs. The average tariff in 2002 was KN1,335 per cubic meter, about 53% of the rate estimated as being necessary in 1993 (KN2,530 in constant 2002 prices) and about 77% of the rate required for the PWUs to break even. The discrepancy with the appraisal estimate arises because Phongsali, Phonhong, and Sayaburi are supplying much less at this stage than envisaged due to high O&M costs. If these towns produce at capacity in 2012, they will require a rate of KN2,141 per cubic meter in constant 2002 prices to break even, closer to the rate envisaged at appraisal. Phongsali has the highest water tariffs, but they are still not nearly enough to cover the high O&M costs. In Phonsavanh, operating costs are low and the tariff (KN1,756 per cubic meter) is sufficient to give a positive FIRR. In Xam Nua, the tariff is also high enough to exceed the average weighted cost of capital of 3%. Compared with some of the water tariffs found by a recent OED impact evaluation study of water supply projects in Asia, which ranged from $0.08 to $0.97 per cubic meter, the average tariff in the seven towns (equivalent to $0.13 per cubic meter) is still low.[26] It is certainly low compared with the cost of a 20-liter container of drinking water, which ranges from KN2,000 to KN3,000 ($0.20 to $0.30), almost 100 times as much.

46. The RRP did not provide EIRR estimates for the Project. The Project was designed to help the Government meet its water supply targets, improve the health of the population, and support economic growth. This was to be achieved through the economic benefits of the additional water supplied by the Project, measured in terms of the resource cost savings for nonincremental supplies in the existing water market and the willingness to pay for incremental drinking water supplied by the Project. Appendix 10 discusses the valuation of these economic benefits and the project costs, along with the economic analyses. The resource cost changes are valued through the time saved in collecting water. The willingness to pay is estimated as not higher than that for the untreated water delivered previously by wells and rivers. Households still have to treat the water delivered by the new systems, and many have now resorted to buying bottled water. One indicator of the low willingness to pay is that the provincial governors are

[25] The latest WASA benefit monitoring and evaluation report on performance indicators does not always reflect these observations in its accounts receivable section.

[26] ADB. 2002. *Impact Evaluation Study on Water Supply and Sanitation Projects in Selected Developing Member Countries.* Manila.

unwilling to approve higher tariffs. Given these circumstances, the finding that only one of the seven PWUs has an EIRR that is above the cutoff value of 12% (Houayxay, at 16.1%) is not surprising. Pakxan manages 10.5% and Phonsavanh reaches 1.7%. The others are negative, and the EIRR of the Project as a whole is also negative.

D. Sustainability

47. The sustainability of the water supply components depends on sufficient water sources, adequate tariffs, and adequate O&M. Several factors suggest that the Project is unlikely to be financially or technically sustainable if current conditions persist. These include insufficient water sources in some cases, insufficient tariffs in most cases, inadequately trained staff, inappropriate reference materials, design flaws, and inappropriate maintenance (Appendixes 3 and 6).

48. Most of these factors could be improved to the point that the Project becomes sustainable. Staff could be trained better, and several agencies are already providing support in this area, e.g., the Japan International Cooperation Agency. O&M manuals suitable for Lao operators have yet to be produced. Once improved O&M starts to show results in relation to the quality of service, tariffs could be raised to levels that would generate sufficient funds for full cost recovery. WASA is currently preparing a water tariff policy that it hopes will address the issue of automatic cost adjustments. While this will certainly improve the likelihood of financial sustainability, higher tariffs will most likely have their intended effect when the water delivered is of satisfactory quality. This implies that the water distributed in the towns should be fully disinfected. Most of the design flaws can also be corrected. In Pakxan, individual pump-to-waste facilities could be retrofitted relatively inexpensively and operated manually. In Phonhong and Sayaburi, all automatic features would have to be restored to provide the basis for efficient operation. This would require some special training. Pump-to-waste piping and valves could be retrofitted. In the other towns, filter boxes could be raised, piping added, and sand changed to produce slow sand filters, thereby more closely matching the norm for well-functioning filters than what was provided for under the Project.[27] Slow sand filter plants are deceptively simple, but require careful O&M techniques. Staff require some further training.

49. The Phongsali raw water supply system is unfortunately of such an expensive design that it cannot be made economically viable. Phongsali already has the highest tariffs. The PWU will need government subsidies to keep up with its considerable operating costs. Even when the three stations are converted to electric power, which is now under way, electricity costs will be inordinately high, because the cost of the power to lift the water 600 meters is about 10 times that of an average system. In addition, maintenance of the 6-km access road will also require considerable expenditure. Reverting to sources at higher levels is possible, even taking impounding into account. This option would, however, be associated with further costs that may exceed cost savings, and would therefore be uneconomical. Water sources closer to the level of the town must be re-investigated and the maximum benefit derived from these.

[27] These comments are made without the benefit of studying the loan consultant's design notes and assumptions, which might shed some different light on what appear to be design flaws. In particular, why the loan consultant would have specified the same sand characteristics for both the first- and second-stage filters is unclear. The dimensions (and consequently higher hydraulic loading rate for the first stage) indicate that the first-stage filter was intended to be a roughing filter. As such, filling the first-stage filter with coarser sand and the second-stage filter with finer sand would have been more appropriate.

IV. ACHIEVEMENT OF OTHER DEVELOPMENT IMPACTS

A. Socioeconomic and Sociocultural Impacts

50. The Project was designed to improve the urban environment and catalyze productivity through improved health gains. The urban environment was improved in a broad sense through the convenience of piped water supply to individual houses and government facilities. The diligence with which most consumers are paying the tariffs could be interpreted as a sign of satisfaction by the population served. However, if the basic project purpose of a safe, reticulated water supply is translated into a more results-oriented objective of a number of people drinking safe water directly from the tap in their house, then this has not been achieved in any of the project towns. The estimate by the PWUs is that more than 95% of the population served does not drink water from the tap without boiling it first, and most have resorted to buying bottled water, which has become available in many parts of the Lao PDR. The Project's water quality is not fully trusted even by most of the PWU directors, but resistance to the smell of chlorinated water is a complicating factor. In some towns, households are increasingly using water filters. Thus, the Project's health gains from drinking safe water are suboptimal, although the availability of adequate quantities of water for washing will have distinct hygienic, and therefore health, effects. Unfortunately, the benefit monitoring and evaluation reports submitted annually by the PWUs do not systematically capture health effects. Some data for four towns have been reflected in these reports. These do not support the hypothesis that the Project has had major health effects. Whereas the incidence of malaria seems to have gone down slightly from 1.7% of households being affected in 1996 to 0.8% in 2002, the incidence of diarrhea and dysentery, which are more directly related to water supply, rose slightly from 0.4% of households affected to 0.9%. The quality of the measurements is, however, uncertain. Other health effects were not measured.

51. With the advent of a 24-hour piped water supply, women and children, who often had to fetch water from deep wells near their dwellings and further away from springs or rivers, now have more time to devote to more meaningful endeavors, such as schooling, child rearing, and earning extra income.

52. In all the towns except Phongsali, one or two private producers have become involved in bottling water delivered by the utilities and selling this both to people connected to the system and to people not connected to the system. The bottled water usually receives further treatment through ultraviolet light installations, and the health authorities apparently test it every 6 months. The PWUs have no involvement. The OEM did not check the quality of this treatment process and external testing is inadequate. Despite the risks of direct consumption of such bottled water, this development represents a major benefit to the nonbeneficiaries of the Project. Given the deficient O&M practiced by the PWUs, the better-treated bottled water may even help the users of the piped water system. With proper O&M, including daily testing, the need for such a private supply to these users would be much smaller.

53. The number of users in the towns who can be classified as poor cannot be estimated easily because the benefit monitoring and evaluation reports give disparate data on household incomes in the different towns and do not specify the number of poor users. That 40% of the towns' populations can still be classified as poor in 2002 is conceivable,[28] given that the northern region had the highest percentage (52.5%) of poor in the country in 1997/1998.[29] The towns of Phonsavanh and Phonhong charge lower tariffs for the first 1–10 cubic meters of water

[28] Classified in the PCR as households with an average monthly income of or less than KN60,000 in 2002.
[29] The average for the Lao PDR was around 39% in 1997/1998, compared with 45% in 1992/1993. The incidence of poverty was 41% in rural areas and 26.7% in urban areas.

provided per month, but Houayxay, Sayaburi, and Xam Nua have higher tariffs for the first cubic meters supplied, representing a disadvantage to the poor, who would normally be looking for a lifeline supply. In addition, given the relatively high cost of connection to the system, the piped water supply systems may, in practice, have benefited a smaller portion of low-income groups than the intended 40%. Nevertheless, in a larger sense, the poor must have benefited from the systems because these dramatically increased the supply of water in the towns, improved its quality, and helped generate a supply of bottled water for lifeline purposes.

B. Environmental Impacts

54. The public toilets serve their purposes well, but only a fraction of the intended extensive wastewater drainage system was constructed (para. 22), and most of that was specifically related to the WTP sites. With increasing supply and use of water, the discharge of domestic wastewater in open drains or in improperly maintained septic tanks or soak pits is likely to lead to decreasing sanitary conditions in the towns, although little of this was in evidence and/or reported at the time of the OEM. A significant increase in the use of water is still foreseen. The Project has not fully achieved its intended environmental effects resulting from less use of fuel and fuelwood for boiling water.

C. Impact on Institutions and Policy

55. The Project's impact on institutions and policy relate mainly to the seven towns' growing familiarity with semi-autonomous institutions producing water for sale. This is an achievement in a socialist country that is attempting to adjust to a more market-based economy and that is usually acknowledged to be progressing slowly in this area.[30] However, as the provincial governors still have the final say on the level of the water tariffs and seem to be more favorably disposed to a policy of granting subsidies to compensate for the PWUs' operating losses than to an automatic tariff adjustment mechanism based on increases in O&M costs, there is still some way to go. The decentralization of the water sector in 1998, which was unrelated to the Project, has not had negative consequences for the operation of the water utilities. The Loan Agreement had a covenant that NPL would remain responsible for water supply and for O&M. ADB suggested at the time that the Government should implement the new decentralization policy in a phased manner in tandem with capacity building in the PWUs. The Government did not heed this advice, although WASA has done much to train PWU staff. The OEM regards the decentralization as an ultimately positive development, including WASA's role as regulator. WASA has been particularly important in standardizing and improving the quality of annual income statements and balance sheets, which in the long run will improve financial management.

56. No institutional effects are evident from the repeated benefit monitoring and evaluation exercises. The quality of the socioeconomic data is low and many gaps and inconsistencies are apparent. The quality of the data gathered on financial performance is better, but no analysis has been conducted on financial or socioeconomic data by any organization, whether a PWU or WASA.

V. OVERALL ASSESSMENT

57. **Relevance.** The Project was consistent with ADB's country operational strategy. Moreover, the Project had a poverty-reducing dimension in a broad sense, even though this was

[30] ADB. 2001. *Key Governance Issues in Cambodia, Lao PDR, Thailand, and Viet Nam.* Manila.

not an explicit intention of the country operational strategy at the time. In terms of current ADB strategic priorities, a greater focus on quick expansion of a safe water supply for the poor in particular would have been more appropriate. Even within the project towns, only 56% of the population is currently benefiting from reticulated supply. A greater role for private producers or for the PWUs themselves could have been envisaged, for instance, in extending the service areas by treating and bottling drinking water for sale both inside and outside the towns. Moreover, in three towns the Project relied on high-cost O&M solutions that have necessitated a relatively high tariff and make the new water supply less affordable for the poor than might otherwise have been the case. Note, however, that the supply of bottled water through vendors and shops has increased across the country during the last 5 years, and Nam Papa Vientiane (the water utility for Vientiane) and the private sector have become involved in this, even though this was neither stimulated nor supported by the Project. PWUs have not been involved in testing bottled water. The Project is rated relevant.

58. **Efficacy.** The Project achieved its main output of providing a reticulated water supply to seven provincial towns. The water supply will provide approximately the number of connections intended at project appraisal; however, the water is not bacteriologically safe and is not drunk by the population without further treatment as was intended at appraisal. Nevertheless, plentiful water, whether pristine or not, will have a positive effect on people's physical well-being and health through improvements in personal hygiene. The more peripheral town populations benefited from private sector sales of bottled water obtained from the PWUs, which was of better quality than the untreated water, but was not sufficiently tested. The Project's environmental objective was, therefore, only partly achieved. The provision of some public toilets helped, but the increasing wastewater resulting from the use of piped water in houses is ultimately likely to lead to a deterioration of the urban environment rather than the projected improvement. Effects on deforestation will not have been achieved because of the ongoing need to collect fuelwood to boil water. The objective of fostering community participation in sustaining and enhancing public utility services through a community awareness program was also only partly achieved. Overall, the Project is regarded as broadly efficacious in that at least six of the seven PWUs now provide substantial quantities of piped water directly to households and government facilities and do so on a 24-hour per day basis.

59. **Efficiency.** The economic analysis resulted in a negative EIRR for the Project as a whole, with a positive rate achieved only in Houayxay. The FIRR was similarly negative in six of the seven cases, with a positive return only in Phonsavanh. The investment made in water supply is equivalent to $200 per beneficiary, higher than ADB's average of around $140. This is partly due to the small scale of the schemes. Efficiency of process was limited: because of the lack of hydrogeological data many design changes were made, some not documented and some not justified, as in Phongsali, Phonhong, and Sayaburi. Several towns encountered unforeseen limitations to the water sources. The decision to go for more slow sand filters than intended was appropriate, but the reason why package treatment plants were retained for Phonhong and Sayaburi is unclear. The Project is rated inefficient.

60. **Sustainability.** The Project is not sustainable in several of the towns unless the tariff is increased. None of the towns have instituted an automatic adjustment mechanism for such increases. Given the continued power of the provincial governors to set the tariffs, the autonomy needed for viable operation of the PWUs is limited. WASA's current initiative of developing a water tariff policy (i.e., higher tariffs) is promising, but will have to be accompanied by improved service delivery if it is to lead to higher incomes. The enthusiasm for disinfecting water within the PWUs is low, as this will incur further costs and require the organization of awareness campaigns. As the systems age, the likelihood of poorer supply and more frequent breakdowns increases. Five of the seven water utilities reported losses on their 2002 income statements if

the loan interest and principal repayments, then due, were included. The lack of financial viability of the water utilities is already affecting the operation of some water supply systems through neglect of necessary maintenance. Technical sustainability is an issue in all cases, but especially for the four towns with plants with high mechanical content. Under these conditions, the Project is less likely to be sustainable.

61. **Institutional Development and Other Impacts.** The Project's aims were modest in relation to institutional development, but its achievements were substantial. The training and awareness components of the TA were not very effective and site-specific manuals were not prepared, but improvements have taken place in relation to financial management compared with the situation a few years ago. In a wider sense, growing experience with the production of cleaner water because of filtration and private provision of bottled water can be linked to projects started in the 1990s across the country, of which the Project under discussion is but one.

62. **Overall Project Rating.** When rated in accordance with OED's standard weighting system,[31] the Project is partly successful, although bordering on successful. [32]

63. **Assessment of ADB and Borrower Performance.** ADB's performance was partly satisfactory. ADB undertook 11 review missions during 1994–1999 and provided guidance and support to project staff and NPL management. Given NPL's limited capacity at the time, this was appropriate and ensured that the project outputs of the water supply component were largely achieved. However, PPTA should have placed much more emphasis on collecting hydrogeological data. The drainage component was not properly prepared. A test drilling program was subsequently not included in ADB's project design, nor was the recommended emphasis on water level monitoring. The need for the sanitation component was insufficiently checked and was overestimated in the RRP. No ADB staff visited Phongsali during the project period because of the difficulty of reaching it at the time. This was, however, the place where a major change was made to the project predesign that was insufficiently justified and resulted in an unsustainable situation. The period of the international consultancy should have been extended longer, and ADB should have pushed for this harder.

64. The Government, the Executing Agency, and the Implementing Agency lacked the experience and skilled personnel to implement the Project efficiently. The PIOs were particularly weak. In Phongsali, this lack of experience seems to have contributed to the situation whereby the Government discouraged consultants from assessing some areas that could have provided more spring water at a higher elevation. There was also little understanding of, and support for, the CAEP on the part of the Government. However, the objective of the Project was in part to develop management capacity, and over time, some was indeed built up. This conclusion is also based on experience with other ADB projects in the sector. WASA took over the important role of training and regulating the PWUs. O&M manuals should have been insisted upon. Overall, the implementation performance of the Government was satisfactory, but only just.

[31] ADB. 2000. *Guidelines for the Preparation of Project Performance Audit Reports.* Manila (Table 1). Available: http://www.adb.org/Documents/Guidelines/PPAR/default.asp?p=evaltool

[32] On a scale of four categories: highly successful, successful, partly successful, and unsuccessful.

VI. ISSUES, LESSONS, AND FOLLOW-UP ACTIONS

A. Key Issues for the Future

1. Mode of Water Supply

65. The mode of water supply in developing countries should be carefully considered by governments and ADB. Whereas in most industrial countries, governments have decided to pipe potable[33] water to every household to be used for all sorts of activities that do not require drinking the water, another approach may sometimes be more appropriate in developing countries. Water that is treated to a lesser standard, perhaps only to reduce objectionable color and remove suspended solids to result in, say, 15 nephelometric turbidity units,[34] could be piped into households. The same water utility could treat a smaller quantity of water to internationally recognized drinking water standards, which are far more stringent than World Health Organization standards, and then sell that water in bottles at a cost that reflects full cost recovery, including return on capital, but without excessive commercial profiteering. (Appendix 11 compares certain drinking water standards and recommends standards for adoption by the Lao PDR for at least the bottled water option.) The practice in even a poor country such as the Lao PDR has shown that buying and drinking bottled water is now widespread and that even poor people are willing to pay for bottled water. Currently, the price of potable water in a 20-liter container is equivalent to $0.25 and a 0.95 liter bottle costs $0.12. The practice would have the added benefit of allowing more rapid fulfillment of the needs of a peri-urban, rural, and scattered population than piped systems concentrated in town centers.[35]

2. Water Tariffs

66. The water tariffs need to be raised to a level sufficient to cover investment repayment and O&M costs. This is essential for the sustainability of the water supply projects. Subsidies to the nonpoor through tariffs should be reduced.

B. Lessons Identified

67. In deciding on the mode of water supply for water supply projects, not only should the willingness to pay for water and the water supply management capacity be taken into account, but so should the culture surrounding water consumption. For example, some cultures may rely on drinking boiled water as tea rather than on drinking chlorinated water from the tap. The high investment costs of producing fully safe drinking water for a small population should be weighed against cheaper and technically less complex solutions that may rely on separate supply systems for nondrinking use and for the production of modest amounts of odor-free, safe water for distribution to a wider population in tanks and bottles.

68. When no hydrogeological data are available, the PPTA for a water supply project should include a period of at least 2 years for collecting such data.

---

[33] By potable, water supply and public health professionals mean water that meets certain quality and aesthetic standards, is free from bacteriological contamination, and is safe for human consumption.

[34] Five is the usual benchmark for this criterion to rate how clear the water is.

[35] However, the economic viability of such an approach has to be demonstrated first, and the actual cost of such a water supply scheme should be subjected to a cost-benefit analysis. Although it seems intuitively obvious that this kind of dual water supply system should be economically superior to the conventional system, this may not always be the case. It may also not be financially superior. The cost of delivering the nonpotable portion may be only marginally less than for potable water. In addition, the margin may not be sufficient to provide the bottled water at an advantageous price. Providing access to the private sector based on competitive tenders may be a viable option, although strict quality assurances, and consequently, monitoring and enforcement, would be necessary components of that option.

69. In developing countries where competent technicians are scarce and where labor costs are low, designers of water supply facilities should focus on low mechanical content, an example of which is the slow sand filter.

70. Water supply and sanitation projects need to devote considerable attention to an adequate CAEP. Even though a population may prove willing to accept the water systems and the tariffs, it should be well informed about the need for and benefits of chlorination and of wastewater drainage.

71. Water supply projects should include sufficient time for international construction supervision, particularly in borrower countries with little experience in this field. Training and water utility-specific sets of operating manuals in the local language must be provided.

C. Follow-Up Actions

72. ADB should study the relevance and feasibility of alternative systems to make cheap, safe drinking water available to the poor as part of its poverty reduction strategy. A pilot initiative could be implemented in 2004. Guidelines should be developed afterward, possibly through a regional TA. The guidelines could include setting standards for water treatment and quality control for piped and bottled water.[36]

73. The follow-up actions noted below should be WASA initiatives that could be sponsored and monitored by ADB during 2004 and 2005, possibly as part of a project.

(i) Site-specific, comprehensive O&M manuals in Laotian should be produced. The cost to produce all seven may be around $180,000. Staff training should be provided based on the manuals. This would have to be an ongoing program and be associated with certification at different levels. Ideally, technical schools should offer such training.

(ii) The designs of the water supply system can be improved, and this should be considered. The cost for this may be around $700,000, including engineering and construction supervision.

(iii) Application of test procedures, disinfection methods, and record keeping should be enforced and monitored. The development of standards and monitoring and enforcement protocols is a prerequisite. When adequately filtered and chlorinated water is tested regularly and found to be in order, a campaign should be launched to create more acceptance of drinking water from the tap. Water education under ADB's Water for Asian Cities Program could cover this, and WASA could apply for funding out of this program. Drinking water directly from the tap without boiling it instead of buying bottled water might lead to annual savings of around $40 per household, which is 2–3% of the average annual income per household.

(iv) The automatic tariff adjustment mechanism covenanted in the Loan Agreement for the Project needs to be put in place in all the towns. Since the decentralization, cross-subsidies between water utilities will no longer take place. Government subsidies to remedy cash flow shortages should be avoided.

[36] See also the action plan on page 22 of the OED study referred to in footnote 26.

PROJECT COSTS AS APPRAISED AND ACTUAL

($ million)

Component	At Appraisal			Actual			
				ADB		Govt.	
	Foreign	Local	Total	Foreign	Local	Local	Total
A. Base Cost							
1. Land	0.000	0.030	0.030	0.000	0.000	0.177	0.177
2. Civil Works	4.510	2.290	6.800	4.655	0.000	2.864	7.519
3. Equipment and Materials	3.840	0.330	4.170	5.826	0.099	0.000	5.925
4. Consulting Services	0.940	0.710	1.650	1.339	0.492	0.000	1.831
5. Administration	0.070	0.220	0.290	0.042	0.049	0.194	0.285
Subtotal (A)	**9.400**	**3.600**	**13.000**	**11.862**	**0.640**	**3.235**	**15.737**
B. Contingencies							
1. Physical	0.730	0.310	1.040	0.000	0.000	0.000	0.000
2. Price	1.160	0.400	1.560	0.000	0.000	0.000	0.000
Subtotal (B)	**1.890**	**0.710**	**2.600**	**0.000**	**0.000**	**0.000**	**0.000**
C. Service Charge/Interest During Construction	0.360	0.350	0.710	0.148	0.000	0.000	0.148
Subtotal (C)	**0.400**	**0.300**	**0.700**	**0.148**	**0.000**	**0.000**	**0.148**
Total Project Cost	**11.700**	**4.600**	**16.300**	**12.010**	**0.640**	**3.235**	**15.885**

ADB = Asian Development Bank.

Note: Figures may not add up to total because of rounding in the project completion report.

Source: ADB. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila.

PROJECT COMPONENTS AT APPRAISAL AND COMPLETION

Subproject	Per Project Preparatory Technical Assistance	As Constructed
Houayxay	Pontoon river pump station Rapid sand filtration WTP Two diesel generator sets for pump stations Gravity to tanks 10.5 km pipe for 1,050 service connections	Spring source Two-stage slow sand filtration WTP Retrofitted chemically-assisted sedimentation (currently no chemicals added) Gravity to lower parts of town, one-stage pumping to higher parts 35.4 km pipe for 788 service connections
Pakxan	Pontoon river pump station Rapid sand filtration WTP—2,900 m^3/d Pump station to elevate tanks 11.9 km pipe for 1,500 service connections	Underground source Seven-well field supply including one standby 48.2 km pipe for 1,140 service connections
Phongsali	Rehabilitation of existing system Augmentation from existing spring-fed water storage ponds Chlorination + 1,230 m^3/d WTP Diesel generator for pump stations Distribution to pressure zones 5 km pipe for 740 service connections	Spring source Two-stage slow sand filtration WTP Three-stage pumping (total lift ~ 600 m) Diesel engine-powered, five-stage centrifugal pumps 14.7 km pipe for 594 service connections
Phonhong	Underground source Five-well field supply including one standby Pump station to elevate tanks 8.5 km pipe for 1,080 service connections	River source Rapid sand filtration WTP Three-stage pumping 23.6 km pipe for 807 service connections
Phonsavanh	Weir on water course Rapid sand filtration WTP, pumped backwash Gravity to tank 8.7 km pipe for 2,550 service connections	Spring source Two-stage slow sand filtration 100% gravity system 55.2 km pipe for 1,866 service connections
Sayaburi	Pontoon river pump station Rapid sand filtration WTP—3,520 m^3/d Two diesel generator sets for pump stations Gravity to tanks 16 km pipe for 1,750 service connections	Pontoon river pump station Rapid sand filtration WTP Two-stage pumping Electric motors powered by diesel generators 64.9 km pipe for 1,058 service connections
Xam Nua	Existing dam on river Gravity to WTP Diesel generator set for backwash 320 m pipe + rehabilitation of 950 m pipe for 1,110 service connections	Spring source Two-stage slow sand filtration WTP 100% gravity system 31.4 km pipe for 865 service connections

km = kilometer, m = meter, m^3/d = cubic meter per day, WTP = water treatment plant.

Sources: Operations Evaluation Mission; and BETURE SETAME of France in association with SEATEC of Thailand and SK Consultant of Lao People's Democratic Republic. 1998. Northern Provincial Towns Water Supply and Sanitation Project, *Project Completion Report.* Vientiane.

SUMMARY OF DESIGN FLAWS

Subproject	Flaw
Houayxay	Source insufficient during the dry season, poor filter inlet hydraulics, no convenient hydraulic outlet control, low water depth, no backfilling provision, incorrect first- and second-stage filter media
Pakxan	No individual pump-to-waste facilities at wellheads, no standby hypochlorite solution pump
Phongsali	Source insufficient during the dry season and extreme source water location requiring triple stage pumping to 600 meters head, no standby hypochlorite solution pump, poor filter inlet hydraulics, no convenient hydraulic outlet control, low water depth, no backfilling provision, incorrect first- and second-stage filter media
Phonhong	Raw water intake bay too shallow at low river levels, inaccessibility of pontoon pump station hampers maintenance, triple pumping, complicated package plant, single sedimentation tank, inclined plate separators, no pump-to-waste piping, variable speed pumping, no standby hypochlorite solution pump, no access ladders and platforms
Phonsavanh	Source insufficient during the dry season, poor filter inlet hydraulics, no convenient hydraulic outlet control, low water depth, no backfilling provision, incorrect first- and second-stage filter media
Sayaburi	Inaccessibility of pontoon pump station hampers maintenance, complicated package plant, inclined plate separators, no pump-to-waste piping, variable speed pumping, no standby hypochlorite solution pump, no access ladders and platforms
Xam Nua	Source insufficient during the dry season, poor filter inlet hydraulics, no convenient hydraulic outlet control, low water depth, no backfilling provision, incorrect first- and second-stage filter media

Source: Operations Evaluation Mission.

DESIGN PARAMETERS OF WATER SUPPLY SYSTEMS IN THE SEVEN PROJECT TOWNS

Table A4.1: Water Supply Situation by Town, 1993

Category	Houayxay	Pakxan	Phongsali	Phonhong	Phonsavanh	Sayaburi	Xam Nua	Total
Population	6,004	7,916	4,025	6,460	14,362	9,655	7,335	55,757
Number of Households	1,008	1,286	811	1,043	2,366	1,512	1,138	9,164
Average Household Size	6.0	6.2	5.0	6.2	6.1	6.4	6.4	6.1
Average Household Consumption of Water (liter per day)	301	468	245	365	434	336	370	375
Average Amount Bought from Vendors per Household (liter per day)	24	27	0	32	0	0	0	10
Average Amount Household Collects from Own Well/River/Spring (liter per day)	277	441	245	333	434	336	370	365
Average Household Income per Month (KN)	119,900	127,600	57,100	149,500	82,500	74,500	56,600	93,784
Average Household Income per Year (KN)	1,438,800	1,531,200	685,200	1,794,000	990,000	894,000	679,200	1,125,411
Average Household Income per Hour (10-hour day, KN)	396	421	188	493	272	246	187	310
Cost per Liter from Vendor (KN)	2.0	1.8		1.8				1.8
Cost per Household per Year from Vendors (KN)	17,651	17,374	0	20,440	0	0	0	6,706
Time Needed per Day per Household to Collect Water (minutes)	44	57	71	29	52	50	49	50
Opportunity Cost of Labor per Household per Year to Collect Water from Own Well/River/Spring (80% of market price of water, KN)	84,735	116,136	64,810	70,435	68,904	59,829	44,242	72,526
Economic Cost of Water Consumption per Person per Year (KN)	17,189	21,689	13,059	14,672	11,351	9,369	6,864	13,089
Economic Cost per Person per Year in Constant 2002 Price (KN)	254,125	320,654	193,055	216,913	167,816	138,516	101,477	193,507
Water Consumption per Capita per Year (cubic meter)	18.4	27.8	18.0	21.5	26.1	19.2	21.0	22.5
Economic Cost per Liter from Own Well/River/Spring (KN)	1.2	1.4	1.4	1.7	2.3	2.0	3.1	2.0

KN = kip.

Sources: Operations Evaluation Mission; and BETURE SETAME of France in association with SEATEC of Thailand and SK Consultant of Lao People's Democratic Republic. 1998. Northern Provincial Towns Water Supply and Sanitation Project, *Project Completion Report.* Vientiane.

Table A4.2: Design Capacity of Systems Provided

Category	Houayxay	Pakxan	Phongsali	Phonhong	Phonsavanh	Sayaburi	Xam Nua	Total
Intended Number of Consumers in 2012 per Design	8,290	11,683	5,760	9,592	22,294	19,041	11,532	88,192
Per Capita Demand Project for 2012 (liter per day)	185	206	185	185	206	206	185	
Maximum Amount of Water per Day Available in 2012 per capita	225	249	225	225	249	249	225	
Production Capacity (cubic meter per day)	1,901	3,888	1,296	2,160	5,616	4,320	2,860	22,041
Number of Service Connections Installed Under the Project	788	1,140	594	807	1,866	1,058	865	7,118
Number of Service Connections Provided in the Future	460	679	361	482	1,235	1,683	505	5,405
Total Connections in 2012	1,248	1,819	955	1,289	3,101	2,741	1,370	12,523
Average Household Size with Connections in 2012	6.6	6.4	6.0	7.4	7.2	6.9	8.4	7.1
OED Estimate of Connections in 2002 (domestic and government)	1,182	1,885	832	922	2,044	1,675	2,065	10,605
OED Estimate of Maximum Number of Consumers in 2012	8,290	11,683	5,760	9,592	11,242	19,041	11,532	77,140
OED Estimate of Production Capacity in 2012 (cubic meter per day)	1,901	2,777 [a]	1,296	2,160	2,058 [a]	4,320	2,484 [a]	16,995

OED=Operations Evaluation Department.

[a] In Pakxan, only five of seven wells still give water; spring sources in Phonsavanh has less capacity than assumed at the design stage; in Xam Nua more water than anticipated is being used for irrigation.

Sources: Operations Evaluation Mission; and BETURE SETAME of France in association with SEATEC of Thailand and SK Consultant of Lao People's Democratic Republic. 1998. Northern Provincial Towns Water Supply and Sanitation Project, *Project Completion Report.* Vientiane.

PROCUREMENT SCHEDULE

Contract	Details	Scheduled Date	Achieved Date
A. Mechanical/Electromechanical			
SUP-01 ABC	Polyvinyl chloride/polyethylene pipes, fittings, valves	15 Jul 96	3 Jul 96
SUP-01-D	Steel/ductile iron pipes and fittings	15 Jul 96	5 Jul 96
SUP-01-E	Treatment plant and electromechanical equipment	15 Dec 96	16 Dec 96
IS-02[a]	Vehicles	30 Apr 96	31 May 96
IS-03	Operation and maintenance equipment	30 Apr 96	4 Jun 96
IS-04	Water meters	2 May 97	17 Nov 97
B. Civil Works			
CIV-01	Reservoirs; chlorination facilities; transmission and distribution pipelines; drainage channels; and public toilets in Houayxay, Phongsali, Phonsavanh, and Xam Nua	15 Dec 96	18 Dec 96
CIV-02	Production wells; reservoirs; chlorination facilities; transmission and distribution pipelines; drainage channels; and public toilets in Pakxan, Phonhong, and Sayaburi	15 Feb 97	16 Dec 96
IS-01	Offices, workshops, and stores in all towns:		
	Sayaburi	11 Jun 96	22 Jul 96
	Phonhong	13 Jun 96	12 Jul 96
	Phonsavanh	13 Jun 96	1 Aug 96
	Phongsali	29 Jun 96	30 Sep 96
	Pakxan	5 Jul 96	25 Aug 96
	Houayxay	26 Jul 96	6 Sep 96
	Xam Nua	8 Dec 96	23 Dec 96
FA-01	Headworks, access roads, pipelines in:		
	Phonsavanh	1 Feb 96	2 Feb 96
	Houayxay	3 Jan 97	20 Jan 97
	Xam Nua	29 Jan 97	14 Feb 97
	Phongsali	21 Dec 97	21 Dec 97
FA-02	Install service connections and water meters in all towns	1 Nov 97	various

Sources: Procurement files in Asian Development Bank archives.

OPERATIONAL PROBLEMS IN THE SEVEN WATER UTILITIES

1. In Pakxan, the design did not provide individual pump-to-waste facilities (Photo A6.3, which also shows a messy, uncompleted, typical wellhead). The common pump-to-waste piping with manual valves is not used, possibly because of the inconvenience related to the manual valve operation. Consequently, turbidities are higher than they need to be.

2. In Phonhong and Sayaburi, alum dosing, and hence coagulation, is uneven and not based on jar testing, for which facilities exist, at least at Phonhong (Photo A6.4). In addition, filters are backwashed too frequently and for too long, resulting not only in inefficiencies, but also in potential problems during filter start-ups that, according to provincial water utility staff, are done immediately following backwashing—another operational shortcoming (Photo A6.5).[1] Whether the design included facilities that permit filtering-to-waste was not clear.[2] Filtering-to-waste is an accepted feature that permits disposing of a certain amount of filtered water at the start of a filter run.[3]

3. Because the variable frequency drive has reportedly been damaged by lightning and is therefore disconnected, high-lift pumps at Phonhong are operated manually. To simulate the relatively low flow that would be pumped by one pump running at lower than synchronous speed (at 50 hertz frequency), two pumps are operated at full speed (50 hertz) against almost closed butterfly valves designed for isolation, not throttling (Photo A6.6). The result is an extremely inefficient mode of operation.

4. In Houayxay, Phongsali, Phonsavanh, and Xam Nua, the design appears not to have provided adequate inlet hydraulics, facilities to permit backfilling,[4] sufficient water depth, and the correct sand for the slow sand filters (Photo A6.7). Those shortcomings make efficient operation practically impossible. In addition, operators fill and return cleaned filters online too quickly.[5] Not enough effort and care are applied to maintain a smooth sand surface and an unbroken *schmutzdecke*,[6] and to remove all accumulating debris (flotsam, worms, algal masses, and so on) at inlet piping expeditiously. Photos A6.8 and A6.9 illustrate flotsam at Houayxay and a trampled sand surface at Phongsali, the waterless second-stage tanks being the result of intermittent pumping. Photo A6.8 also shows the retrofitted sedimentation tank.

5. At Phongsali, the diesel engines driving the five-stage pumps are operated at too high a speed (2,500 revolutions per minute versus the nameplate-rated speed of 2,300 revolutions per minute), causing excessive line pressures and diesel fuel consumption, and they are shut off abruptly, potentially causing premature and extremely expensive turbocharger bearing failure.

6. Provincial water utility staff either disinfects insufficiently or not at all (in Pakxan due to mechanical failure and in Phongsali due to government decision). In any case, public pressure against chlorination appears to be the driving force behind this malpractice. Disinfection must be performed adequately, because only then can the water supplies be regarded as bacteriologically safe.

---

[1] Backwashing of rapid sand filters should stop short of attaining crystal-clear backwash water. This is contrary to what many plant operators are likely to do when not aware of the problems that this habit can cause, namely, no solids to provide the equivalent of ripening in a slow sand filter. The consequence of this is the potential for breakthrough of particles that could be pathogenic. Filtering-to-waste is designed to prevent this.

[2] Design briefs were not left behind contrary to contract specifications.

[3] The actual time of filtering-to-waste is based on experience and can be determined analytically based on measurements of the solid content, turbidity, and/or particle count of the filtered water.

[4] After a filter has been cleaned, if the design permits, it is normally brought back online by filling it through the underdrains upward, to displace air.

[5] The usual time quoted in standard texts for bringing a slow sand filter back online after it has ripened is a week.

[6] Literally dirt blanket, that is, a layer of organic mass that constitutes a large part of the filter's removal capacity.

Photo A6.1: Pipe Failure in Houayxay and Sayaburi

Source: Operations Evaluation Mission.

Photo A6.2: Inside the Pump Station in Phongsali

Source: Operations Evaluation Mission.

Photo A6.3: Typical Wellhead in Pakxan

Source: Operations Evaluation Mission.

Photo A6.4: Laboratory Equipment in Phonhong

Source: Operations Evaluation Mission.

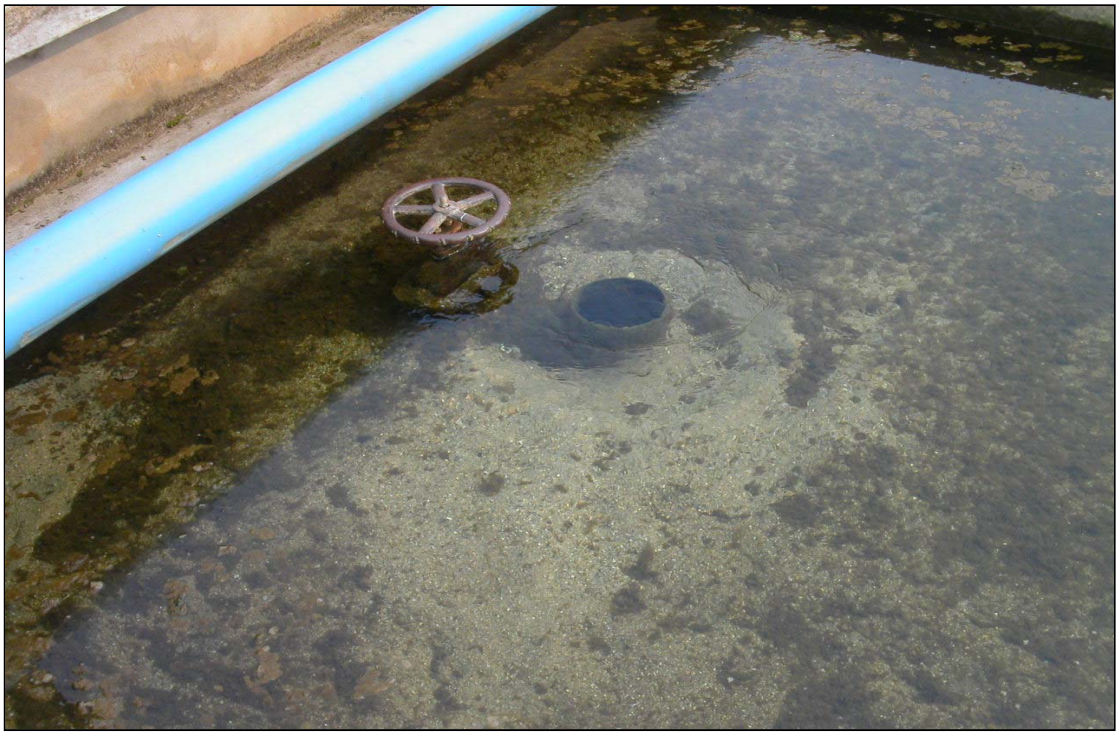
Photo A6.5: Messy Backwashing in Sayaburi

Source: Operations Evaluation Mission.

Photo A6.6: High-Lift Pumps in Phonhong
(Note almost closed butterfly valves and 800 kPa header pressure)

kPa = kilo Pascal.
Source: Operations Evaluation Mission.

Photo A6.7: Typical Slow Sand Filter Inlet Hydraulics in Houayxay
(Note washed out *schmutzdecke*)



Source: Operations Evaluation Mission.

Photo A6.8: Flotsam on First-Stage Slow Sand Filter in Houayxay
(Note retrofitted sedimentation tank in the background)

Source: Operations Evaluation Mission.

Photo A6.9: Two-Stage Slow Sand Filters in Phongsali, Partly Dry Due to Intermittent Pumping
(Note slash and burn haze)

Source: Operations Evaluation Mission.

BASIC DATA ON PROVINCIAL WATER UTILITIES IN THE SEVEN PROJECT TOWNS

Item	Houayxay	Pakxan	Phongsali	Phonhong	Phonsavanh	Sayaburi	Xam Nua	Total
Total Urban Population	11,462	13,378	5,190	9,543	28,056	22,622	15,123	105,374
Urban Population Within Service Area	8,678	11,153	5,184	9,543	28,056	19,218	14,579	96,411
Proportion of Total Urban Population in Service Area (%)	75.7	83.4	99.9	100.0	100.0	85.0	96.4	91.5
Number of Urban Households	1,637	2,511	1,038	1,591	5,053	3,982	2,588	18,400
Number of Service Area Households	1,239	2,092	1,037	1,591	5,053	3,383	2,490	16,885
Number of Domestic Water Meters Connected	1,120	1,829	792	907	1,984	1,618	1,988	10,238
Number of Government Water Meters	62	56	40	15	60	57	77	367
Proportion of Connected Households in Service Area (%)	90.4	87.4	76.4	57.0	39.3	47.8	79.8	60.6
Proportion of Connected Households in Urban Area (%)	68.4	72.8	76.3	57.0	39.3	40.6	76.8	55.6
Population Actually Served in Service Area	5,518	9,749	3,759	7,942	11,349	8,809	11,694	58,820
Projected Number of Connections as per PCR/NPL	868	1,421	696	848	1,819	1,607	1,743	9,002
Hours of Water Supply per Day	24	24	9	24	24	24	24	22
PWU Bottled Water Production	no	no	no	no	no	no	no	0
Other Bottled Water Production	yes	yes	no	yes	yes	yes	yes	6
Total Water Produced (m^3)	525,891	532,136	68,300	218,870	751,000	313,913	341,160	2,751,270
Water Sold, Domestic (m^3)	357,571	308,260	30,121	167,056	544,922	229,879	255,559	1,893,368
Water Sold, Government Facilities (m^3)	89,393	164,288	22,706	23,361	28,718	37,916	42,157	408,539
Unaccounted-for-Water (m^3, %)	15.0	11.2	22.7	13.0	23.6	14.7	13.0	16.3
Average Water Consumed by Households per year (m^3)	319	169	38	184	275	142	129	185
Average Water Consumed per Capita per year (m^3)	65	32	8	21	48	26	22	32
Average Water Consumed per Capita (lpcd)	178	87	22	58	132	71	60	88
Average Water Consumed per Capita in 1999 (lpcd)	190	116	12	48	89	59	60	83
Technical Concerns Expressed to OEM:								
Mentioned First	unclear water	filter not working well	no spare pumps provided	do not like the plant	dirt, leaves	leakage at home connections	leaking with road construction	
Mentioned Second	quality of materials	water not clear	bad access road	parts difficult to get	much cleaning is needed	26 cracks in main pipe	stealing	
Mentioned Third	31 pipe breaks		lot of fuel consumption	pipe bursts		rainy season dirty water	2 breaks per month	

lpcd = liter per capita per day, m^3 = cubic meter, NPL = Nam Papa Lao, OEM = Operations Evaluation Mission, PCR = project completion report, PWU = provincial water utility.

Continued on next page

Table—*Continued*

Item	Houayxay	Pakxan	Phongsali	Phonhong	Phonsavanh	Sayaburi	Xam Nua	Total
Cost of Bottled Water per 0.95-Litre Bottle (KN)	1,500	1,200	2,000	667	1,000	1,250	1,000	1,231
Cost of Bottled Water per 20-Litre Container (KN)	2,500	3,000	—	1,500	3,000	2,000	3,000	2,500
Cost per Service Connection (KN)	460,469	700,000	700,000	600,000	800,000	730,000	965,000	707,924
Number of Septic Tanks/Soak Pits	1,635	2,511	—	838	—	all	2,390	
Length of Wastewater Drainage by Project (m)	250	400	350	1,000	246	800	60	3,106
Length of Wastewater Drainage by Town (m)	0	0	0	0	0	0	0	
Location of Public Toilets	in 2 markets	boat port, bus station	school	near school	bus station, market	2 bus stations	bus station	10
Public Toilets Under Private Lease Agreement (KN/year)	0	0	no	no	50,000	0	360,000	410,000
Wash Areas Constructed Under the Project	0	0	0	1 in hospital	0	0	0	1
Last Tariff Increase Approved by Governor	2000	2001	2000	2000	2001	2001	—	
Average Tariff for Household Connections (KN/m^3)	1,010	1,090	2,200	1,089	1,687	1,600	971	1,378
Average Other Tariffs (KN/m^3)	457	1,324	2,700	983	1,687	1,900	1,100	1,450

— = no data available, KN = kip, m = meter, m^3 = cubic meter.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; ADB. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; and Operations Evaluation Mission.

FINANCIAL STATEMENTS AND DEBT RATIOS FOR THE SEVEN PROJECT TOWNS, 2002

A. Income Statements and Balance Sheets

Table A8.1: Income Statements

Item	Houayxay	Pakxan	Phongsali	Phonhong	Phonsavanh	Sayaburi	Xam Nua
A. Revenue (excluding turnover tax)	**464,428,865**	**671,354,609**	**163,231,177**	**1,069,978,440**	**1,044,703,037**	**556,864,078**	**406,640,659**
Water Sales	370,183,606	515,467,515	105,870,500	834,660,478	855,967,201	445,878,310	304,466,401
Connection Charges	68,609,828	109,591,992	34,096,677	92,683,053	155,913,089	70,823,868	67,863,362
Meter Rental	22,852,000	28,272,325	9,157,000	38,809,232	22,054,500	34,796,000	23,064,190
Other Income (excluding govt. subsidies)	2,783,431	18,022,777	14,107,000	103,825,677	10,768,247	5,365,900	11,246,706
B. Expenditure	**416,047,096**	**441,501,830**	**191,110,796**	**777,741,436**	**438,826,244**	**558,552,283**	**267,029,449**
Personnel	166,102,013	161,446,851	30,638,711	206,226,657	168,058,137	119,734,500	79,395,394
Power	37,397,819	81,265,811	1,422,500	122,289,927	2,971,900	3,656,317	1,465,863
Chemicals	12,870,000	5,739,838	9,263,500	69,820,542	17,655,300	48,350,000	6,629,400
Fuel	28,256,374	28,569,735	100,935,540	34,459,420	20,547,260	157,168,500	8,852,390
Maintenance	58,494,395	1,651,380	23,065,000	55,911,250	34,411,500	65,997,500	10,232,500
Office and Administration	92,049,797	98,962,195	20,147,545	152,434,601	70,748,444	102,784,816	80,605,341
Installation Costs	20,876,698	63,866,020	5,638,000	136,599,039	124,433,703	60,860,650	79,848,561
C. Gross Income (excluding depreciation, finance charges, and tax)	**48,381,769**	**229,852,779**	**(27,879,619)**	**292,237,004**	**605,876,793**	**(1,688,205)**	**139,611,210**
Depreciation	94,427,244	155,185,523	80,058,225	390,760,145	170,980,822	16,671,991	140,769,288
D. Net Operating Income	**(46,045,475)**	**74,667,256**	**(107,937,844)**	**(98,523,141)**	**434,895,971**	**(18,360,196)**	**(1,158,078)**
Net Interest and Finance Charges	(96,842,499)	(88,594,848)		(83,626,224)	(341,363,656)	(9,034,000)	(70,992,336)
Provision for Bad Debts	0	0	0	0	0	0	0
Net Income from Disposal of Assets	0	0	0	0	0	0	0
Increase (Decrease) in Inventory	0	27,341,804	0	118,066,277	(52,455,398)	54,868,100	13,584,664
E. Net Profit (Loss) Before Tax	**(142,887,974)**	**13,414,212**	**(107,937,844)**	**(64,083,088)**	**41,076,917**	**27,473,904**	**(58,565,750)**
Profit Taxes	0	0	0	0	0	0	0
F. Net Profit (Loss) After Tax	**(142,887,974)**	**13,414,212**	**(107,937,844)**	**(64,083,088)**	**41,076,917**	**27,473,904**	**(58,565,750)**
Government Subsidies	0	0	79,600,000	0	0	0	0
G. Net Profit (Loss)	**(142,887,974)**	**13,414,212**	**(28,337,844)**	**(64,083,088)**	**41,076,917**	**27,473,904**	**(58,565,750)**
H. Turnover Tax to the Government	**0**	**0**	**0**	**0**	**0**	**0**	**0**
I. Salary Tax	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Source: Water Supply Authority.

Table A8.2: Balance Sheets

Item	Houayxay	Pakxan	Phongsali	Phonhong	Phonsavanh	Sayaburi	Xam Nua
A. Fixed Assets							
Land						152,712,000	
Buildings, Plant, and Equipment	3,335,054,545	4,326,214,627	2,991,473,524	6,764,705,142	5,109,846,849	5,386,718,634	3,740,802,796
Less: Depreciation	350,506,882	598,866,881	462,327,758	757,503,395	170,980,822	32,952,091	309,815,994
Net Fixed Assets	2,984,547,663	3,727,347,746	2,529,145,766	6,007,201,747	4,938,866,027	5,353,766,543	3,430,986,802
Work in Progress	0	0	0	0	0	0	0
Subtotal	**2,984,547,663**	**3,727,347,746**	**2,529,145,766**	**6,007,201,747**	**4,938,866,027**	**5,506,478,543**	**3,430,986,802**
B. Current Assets							
Inventory	197,341,982	126,632,123	107,213,964	246,251,015	1,135,133,237	17,546,030	71,565,459
Debtors	154,942,866	74,726,357	45,073,598	861,278,353	524,882,719	160,374,632	62,879,846
Advance	0	0	16,603,170	49,528,545	7,403,000	80,000,000	0
Cash	31,760,549	240,415,168	29,477,027	322,183,718	525,724,260	80,168,058	260,036,890
Subtotal	**384,045,397**	**441,773,648**	**198,367,759**	**1,479,241,631**	**2,193,143,216**	**338,088,720**	**394,482,195**
Total Assets (fixed plus current)	**3,368,593,060**	**4,169,121,394**	**2,727,513,525**	**7,486,443,378**	**7,132,009,243**	**5,844,567,263**	**3,825,468,997**
C. Current Liabilities[a]							
Creditors	95,343,259	274,332,243	(389,034)	873,552,597	9,331,955	134,607,147	2,541,392
Subtotal	**95,343,259**	**274,332,243**	**(389,034)**	**873,552,597**	**9,331,955**	**134,607,147**	**2,541,392**
D. Net Current Assets	**288,702,138**	**167,441,405**	**198,756,793**	**605,689,034**	**2,183,811,261**	**203,481,573**	**391,940,803**
Total Assets Less Current Liabilities	**3,273,249,801**	**3,894,789,151**	**2,727,902,559**	**6,612,890,781**	**7,122,677,288**	**5,709,960,116**	**3,822,927,605**
E. Liabilities							
Long-Term Loan	2,876,840,636	1,465,136,549	2,460,367,417	3,873,906,141	4,266,843,014	3,779,175,563	1,282,138,687
F. Equity							
Capital (Government)	836,799,869	2,707,481,366	712,576,571	2,751,603,249	2,814,242,105	1,891,259,799	2,836,093,582
Accumulated Profit/Losses	(440,390,704)	(277,828,764)	(445,041,429)	(345,123,384)	41,076,917	27,493,904	(326,265,686)
Reserves	0	0	0	332,504,775	515,252	12,030,850	30,961,022
Subtotal	**396,409,165**	**2,429,652,602**	**267,535,142**	**2,738,984,640**	**2,855,834,274**	**1,930,784,553**	**2,540,788,918**
Total Liabilities (liabilities plus equity)	**3,273,249,801**	**3,894,789,151**	**2,727,902,559**	**6,612,890,781**	**7,122,677,288**	**5,709,960,116**	**3,822,927,605**

[a] Amounts falling due within 1 year.

Source: Water Supply Authority.

B. Debt Ratios

1. The calculations of debt ratios relied on the 2002 consolidated income statement and balance sheet for the seven towns as submitted by the Water Supply Authority. For debt service, an annual average sum was calculated and used, because the debt service reflected in the statements for 2002 sometimes differed substantially from the average. Of the seven towns, four (Pakxan, Phonhong, Phonsavanh, and Xam Nua) had a debt-service coverage ratio of more than 1.2:1 in 2002. The expenditures of Phongsali and Sayaburi were far greater than their revenues, resulting in negative debt service ratios. Thus overall, the Project's debt-service coverage ratio was calculated as 1.5 in 2002 (Table A8.3).

Table A8.3: Debt Ratios for the Seven Project Towns, 2002

Town	Debt-Equity Ratio	Debt-Service Coverage Ratio
Houayxay	88:12	0.40
Pakxan	42:58	3.30
Phongsali	90:10	(0.30)
Phonhong	63:37	1.50
Phonsavanh	60:40	3.50
Sayaburi	67:33	(0.01)
Xam Nua	34:66	2.70
Total	**62:38**	**1.50**

Source: Operations Evaluation Mission, based on data supplied by the Water Supply Authority.

2. In 2002, all the project towns except Houayxay and Phongsali met the debt-equity covenant. As a result, the Project's debt-equity ratio of 62:38 in 2002 was still within the 70:30 covenant. The most leveraged town was Phongsali, followed by Houayxay, with total liabilities around nine and seven times their respective equities.

FINANCIAL INTERNAL RATES OF RETURN

1. Commercial operations of the water supply systems commenced in 1999. The Project generates revenues from the sale of water, new connections, and meter rental. Capital costs include investments in the development of water supply systems and environmental improvements. Operation and maintenance costs include salaries and wages, power/fuel, chemicals, and the cost of new connections. Only costs and revenues related to new systems have been included in the calculation of the financial internal rate of return (FIRR). The following assumptions were made in calculating the Project's FIRR:

(i) The Project has a useful life of 25 years. Full capacity utilization is expected by 2012.
(ii) Water tariffs will remain at their 2002 levels until the end of the useful life of the Project.
(iii) New connections will increase to reach the design capacity of the water supply system in each town in construction horizon year 2012. Meanwhile, income from meter rentals will increase in proportion with the number of new connections each year.

2. Tables A9.1 to A9.9 provide the details of the calculations for the Project as a whole and for each town. Costs and revenues are expressed in constant 2002 prices. The FIRR for the Project as a whole was negative, because six of the seven towns posted negative rates of return. Only Phonsavanh recorded a positive FIRR of 7.3% (Table A9.1).

Table A9.1: Financial Internal Rate of Return
(%)

Town	PCR	PPAR
Houayxay	7.2	negative
Pakxan	(0.03)	(1.2)
Phongsali	(1.2)	negative
Phonhong	negative	negative
Phonsavanh	3.3	7.3
Sayaburi	(3.2)	negative
Xam Nua	(1.9)	(0.2)
Project	—	negative

— = not calculated, PCR = project completion report, PPAR = project performance audit report.

Source: Operations Evaluation Mission calculations.

Table A9.2: Houayxay
(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Average Tariff (KN/m^3)	AC (no.)	Revenue (KN million)					Cost (KN million)			Net Benefit (KN million)
					From Water Sales	Per Service Connection	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	260.5	0.0	260.5	(260.5)
1996	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	385.0	0.0	385.0	(385.0)
1997	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	2,224.2	0.0	2,224.2	(2,224.2)
1998	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	901.0	0.0	901.0	(901.0)
1999	276.3	93.8	1,446	718	135.5	0.3	220.9	7.1	363.6	60.1	156.2	216.3	147.2
2000	382.5	322.6	859	103	277.1	0.4	39.6	12.1	328.9	0.0	273.0	273.0	55.9
2001	471.0	353.2	737	208	260.2	0.4	86.8	18.2	365.2	0.0	113.0	113.0	252.3
2002	525.9	447.0	926	143	413.9	0.5	65.8	22.9	502.6	0.0	416.0	416.0	86.5
2003	542.7	461.2	926	8	427.1	0.5	3.5	23.0	453.6	0.0	429.3	429.3	24.2
2004	559.5	475.5	926	8	440.3	0.5	3.5	23.1	467.0	0.0	442.6	442.6	24.3
2005	576.3	489.8	926	8	453.6	0.5	3.5	23.3	480.3	0.0	455.9	455.9	24.4
2006	593.1	504.1	926	8	466.8	0.5	3.5	23.4	493.7	0.0	469.2	469.2	24.5
2007	609.9	518.4	926	8	480.0	0.5	3.5	23.6	507.1	0.0	482.5	482.5	24.6
2008	626.7	532.7	926	8	493.2	0.5	3.5	23.7	520.4	0.0	495.8	495.8	24.7
2009	643.5	546.9	926	8	506.5	0.5	3.5	23.9	533.8	0.0	509.1	509.1	24.7
2010	660.3	561.2	926	8	519.7	0.5	3.5	24.0	547.2	0.0	522.4	522.4	24.8
2011	677.1	575.5	926	8	532.9	0.5	3.5	24.2	560.6	0.0	535.6	535.6	24.9
2012	693.9	589.8	926	8	546.1	0.5	3.5	24.3	573.9	0.0	548.9	548.9	25.0
2013	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2014	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2015	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2016	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2017	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2018	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2019	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2020	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2021	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2022	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
2023	693.9	589.8	926	0	546.1	0.5	0.0	24.3	570.5	0.0	548.9	548.9	21.5
												FIRR (%)	**negative**

AC = additional connection, FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A9.3: Pakxan

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Average Tariff (KN/m^3)	AC (no.)	Revenue (KN million)					Cost (KN million)			Net Benefit (KN million)
					From Water Sales	Per Service Connection	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	345.6	0.0	345.6	(345.6)
1996	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	510.8	0.0	510.8	(510.8)
1997	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	2,951.1	0.0	2,951.1	(2,951.1)
1998	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	1,195.5	0.0	1,195.5	(1,195.5)
1999	262.8	249.0	718	1,298	178.9	0.5	607.2	10.2	796.3	59.5	477.6	537.1	259.2
2000	420.2	363.5	1,158	174	421.1	0.6	101.8	17.4	540.2	0.0	596.6	596.6	(56.4)
2001	436.7	410.9	1,292	193	530.6	0.6	122.5	23.5	676.7	0.0	668.5	668.5	8.2
2002	532.1	472.5	1,208	149	570.8	0.7	104.3	28.3	703.4	0.0	441.5	441.5	261.9
2003	580.3	515.5	1,208	43	622.7	0.7	29.8	28.9	681.4	0.0	481.5	481.5	200.0
2004	628.4	558.5	1,208	43	674.6	0.7	29.8	29.6	734.0	0.0	521.4	521.4	212.6
2005	676.6	601.4	1,208	43	726.5	0.7	29.8	30.3	786.5	0.0	561.4	561.4	225.2
2006	724.7	644.4	1,208	43	778.4	0.7	29.8	30.9	839.1	0.0	601.3	601.3	237.8
2007	772.9	687.4	1,208	43	830.3	0.7	29.8	31.6	891.7	0.0	641.3	641.3	250.4
2008	821.0	730.3	1,208	43	882.2	0.7	29.8	32.2	944.2	0.0	681.2	681.2	263.0
2009	869.2	773.3	1,208	43	934.1	0.7	29.8	32.9	996.8	0.0	721.2	721.2	275.6
2010	917.4	816.2	1,208	43	986.0	0.7	29.8	33.6	1,049.3	0.0	761.1	761.1	288.2
2011	965.5	859.2	1,208	43	1,037.9	0.7	29.8	34.2	1,101.9	0.0	801.1	801.1	300.8
2012	1,013.7	902.2	1,208	43	1,089.8	0.7	29.8	34.9	1,154.4	2,013.8	841.0	2,854.8	(1,700.4)
2013	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2014	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2015	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2016	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2017	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2018	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2019	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2020	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2021	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2022	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
2023	1,013.7	902.2	1,208	0	1,089.8	0.7	0.0	34.9	1,124.7	0.0	841.0	841.0	283.7
												FIRR (%)	**(1.2)**

AC = additional connection, FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A9.4: Phongsali
(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Average Tariff (KN/m^3)	AC (no.)	Revenue (KN million)					Cost (KN million)			Net Benefit (KN million)
					From Water Sales	Per Service Connection	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	306.9	0.0	306.9	(306.9)
1996	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	453.6	0.0	453.6	(453.6)
1997	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	2,620.5	0.0	2,620.5	(2,620.5)
1998	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	1,061.6	0.0	1,061.6	(1,061.6)
1999	19.3	13.1	2,694	594	35.3	0.5	277.9	3.5	316.6	70.9	131.2	202.1	114.5
2000	40.1	31.0	2,632	130	81.7	0.6	76.1	6.4	164.1	0.0	149.6	149.6	14.5
2001	54.0	41.8	2,757	14	115.2	0.6	8.9	7.7	131.8	0.0	159.9	159.9	(28.1)
2002	68.3	52.8	2,004	53	105.9	0.7	37.1	9.2	152.1	0.0	191.1	191.1	(39.0)
2003	108.8	84.0	2,004	40	168.3	0.7	27.9	9.6	205.8	0.0	304.4	304.4	(98.5)
2004	149.2	115.1	2,004	40	230.7	0.7	27.9	10.1	268.7	0.0	417.6	417.6	(148.9)
2005	189.7	146.3	2,004	40	293.1	0.7	27.9	10.5	331.6	0.0	530.9	530.9	(199.3)
2006	230.2	177.4	2,004	40	355.5	0.7	27.9	11.0	394.4	0.0	644.1	644.1	(249.7)
2007	270.7	208.5	2,004	40	417.9	0.7	27.9	11.5	457.3	0.0	757.4	757.4	(300.1)
2008	311.1	239.7	2,004	40	480.3	0.7	27.9	11.9	520.2	0.0	870.6	870.6	(350.4)
2009	351.6	270.8	2,004	40	542.7	0.7	27.9	12.4	583.0	0.0	983.9	983.9	(400.8)
2010	392.1	302.0	2,004	40	605.1	0.7	27.9	12.9	645.9	0.0	1,097.1	1,097.1	(451.2)
2011	432.6	333.1	2,004	40	667.5	0.7	27.9	13.3	708.8	0.0	1,210.4	1,210.4	(501.6)
2012	473.0	364.2	2,004	40	729.9	0.7	27.9	13.8	771.6	2,416.6	1,323.6	3,740.2	(2,968.5)
2013	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2014	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2015	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2016	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2017	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2018	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2019	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2020	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2021	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2022	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
2023	473.0	364.2	2,004	0	729.9	0.7	0.0	13.8	743.7	0.0	1,323.6	1,323.6	(579.9)
												FIRR (%)	**negative**

AC = additional connection, FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A9.5: Phonhong

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Average Tariff (KN/m^3)	AC (no.)	Revenue (KN million)					Cost (KN million)			Net Benefit (KN million)
					From Water Sales	Per Service Connection	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	383.5	0.0	383.5	(383.5)
1996	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	566.8	0.0	566.8	(566.8)
1997	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	3,274.2	0.0	3,274.2	(3,274.2)
1998	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	1,326.4	0.0	1,326.4	(1,326.4)
1999	101.6	89.2	507	678	45.3	0.4	271.8	14.3	331.4	88.5	161.0	249.5	82.0
2000	140.7	122.9	1,287	83	158.3	0.5	41.6	24.1	224.0	0.0	338.1	338.1	(114.1)
2001	185.7	162.0	1,187	84	192.2	0.5	45.7	32.0	269.9	0.0	516.3	516.3	(246.4)
2002	218.9	190.4	1,076	84	204.9	0.6	50.4	38.8	294.1	0.0	692.5	692.5	(398.4)
2003	275.8	240.0	1,076	27	258.2	0.6	16.0	39.9	314.1	0.0	872.7	872.7	(558.6)
2004	332.8	289.5	1,076	27	311.5	0.6	16.0	41.0	368.5	0.0	1,052.9	1,052.9	(684.4)
2005	389.7	339.1	1,076	27	364.8	0.6	16.0	42.1	422.9	0.0	1,233.1	1,233.1	(810.2)
2006	446.7	388.6	1,076	27	418.1	0.6	16.0	43.3	477.4	0.0	1,413.3	1,413.3	(935.9)
2007	503.6	438.2	1,076	27	471.5	0.6	16.0	44.4	531.8	0.0	1,593.5	1,593.5	(1,061.7)
2008	560.6	487.7	1,076	27	524.8	0.6	16.0	45.5	586.2	0.0	1,773.7	1,773.7	(1,187.5)
2009	617.5	537.3	1,076	27	578.1	0.6	16.0	46.6	640.6	0.0	1,953.9	1,953.9	(1,313.3)
2010	674.5	586.8	1,076	27	631.4	0.6	16.0	47.7	695.1	0.0	2,134.1	2,134.1	(1,439.0)
2011	731.4	636.4	1,076	27	684.7	0.6	16.0	48.8	749.5	0.0	2,314.3	2,314.3	(1,564.8)
2012	788.4	685.9	1,076	27	738.0	0.6	16.0	49.9	803.9	4,403.0	2,494.5	6,897.5	(6,093.6)
2013	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2014	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2015	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2016	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2017	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2018	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2019	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2020	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2021	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2022	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
2023	788.4	685.9	1,076	0	738.0	0.6	0.0	49.9	788.0	0.0	2,494.5	2,494.5	(1,706.5)
											FIRR (%)		**negative**

AC = additional connection, FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A9.6: Phonsavanh

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Average Tariff (KN/m^3)	AC (no.)	Revenue (KN million)					Cost (KN million)			Net Benefit (KN million)
					From Water Sales	Per Service Connection	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	386.3	0.0	386.3	(386.3)
1996	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	570.9	0.0	570.9	(570.9)
1997	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	3,298.0	0.0	3,298.0	(3,298.0)
1998	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	1,336.0	0.0	1,336.0	(1,336.0)
1999	453.0	307.1	819	1,392	251.3	0.5	744.2	7.1	1,002.6	89.2	107.3	196.5	806.1
2000	516.0	395.0	629	383	248.6	0.7	256.1	13.5	518.2	0.0	472.9	472.9	45.3
2001	611.0	463.0	706	326	326.8	0.7	236.5	19.1	582.4	0.0	616.6	616.6	(34.1)
2002	751.0	573.6	1,756	93	1,007.3	0.8	74.4	22.1	1,103.8	0.0	438.8	438.8	664.9
2003	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2004	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2005	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2006	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2007	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2008	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2009	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2010	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2011	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2012	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2013	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2014	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2015	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2016	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2017	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2018	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2019	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2020	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2021	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2022	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
2023	751.0	573.6	1,756	0	1,007.3	0.8	0.0	22.1	1,029.4	0.0	438.8	438.8	590.5
												FIRR (%)	**7.3**

AC = additional connection, FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A9.7: Sayaburi

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Average Tariff (KN/m^3)	AC (no.)	Revenue (KN million)					Cost (KN million)			Net Benefit (KN million)
					From Water Sales	Per Service Connection	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	424.1	0.0	424.1	(424.1)
1996	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	626.8	0.0	626.8	(626.8)
1997	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	3,621.4	0.0	3,621.4	(3,621.4)
1998	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	1,467.0	0.0	1,467.0	(1,467.0)
1999	163.6	133.8	1,588	1,199	212.4	0.5	584.9	12.8	810.1	97.9	380.9	478.9	331.3
2000	234.6	205.9	1,755	172	361.4	0.6	104.9	14.4	480.8	0.0	323.1	323.1	157.7
2001	234.3	214.9	1,864	172	400.6	0.7	113.8	29.5	543.9	0.0	355.3	355.3	188.6
2002	313.9	267.8	1,690	109	452.6	0.7	79.6	34.8	566.9	0.0	558.6	558.6	8.4
2003	440.2	375.0	1,690	155	633.8	0.7	113.4	38.1	785.3	0.0	783.3	783.3	2.1
2004	566.5	482.3	1,690	155	815.1	0.7	113.4	41.3	969.9	0.0	1,008.0	1,008.0	(38.1)
2005	692.8	589.5	1,690	155	996.3	0.7	113.4	44.6	1,154.4	0.0	1,232.7	1,232.7	(78.3)
2006	819.1	696.8	1,690	155	1,177.6	0.7	113.4	47.9	1,338.9	0.0	1,457.4	1,457.4	(118.5)
2007	945.4	804.0	1,690	155	1,358.8	0.7	113.4	51.2	1,523.4	0.0	1,682.1	1,682.1	(158.7)
2008	1,071.6	911.3	1,690	155	1,540.1	0.7	113.4	54.4	1,707.9	0.0	1,906.8	1,906.8	(198.9)
2009	1,197.9	1,018.5	1,690	155	1,721.3	0.7	113.4	57.7	1,892.5	0.0	2,131.5	2,131.5	(239.0)
2010	1,324.2	1,125.8	1,690	155	1,902.6	0.7	113.4	61.0	2,077.0	0.0	2,356.2	2,356.2	(279.2)
2011	1,450.5	1,233.0	1,690	155	2,083.8	0.7	113.4	64.3	2,261.5	0.0	2,580.9	2,580.9	(319.4)
2012	1,576.8	1,340.3	1,690	155	2,265.1	0.7	113.4	67.5	2,446.0	4,403.0	2,805.6	7,208.6	(4,762.6)
2013	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2014	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2015	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2016	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2017	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2018	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2019	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2020	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2021	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2022	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
2023	1,576.8	1,340.3	1,690	0	2,265.1	0.7	0.0	67.5	2,332.6	0.0	2,805.6	2,805.6	(473.0)
												FIRR (%)	**negative**

AC = additional connection, FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A9.8: Xam Nua

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Average Tariff (KN/m^3)	AC (no.)	Revenue (KN million)					Cost (KN million)			Net Benefit (KN million)
					From Water Sales	Per Service Connection	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	275.5	0.0	275.5	(275.5)
1996	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	407.1	0.0	407.1	(407.1)
1997	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	2,351.9	0.0	2,351.9	(2,351.9)
1998	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	952.7	0.0	952.7	(952.7)
1999	246.0	198.0	510	1,389	101.0	0.6	895.7	8.0	1,004.7	63.6	246.4	310.0	694.8
2000	279.7	209.1	653	369	136.6	0.8	297.6	15.1	449.3	0.0	313.9	313.9	135.4
2001	315.0	291.6	599	127	174.7	0.9	111.1	19.4	305.2	0.0	398.1	398.1	(92.9)
2002	341.2	297.7	1,071	144	318.9	1.0	139.0	23.1	480.9	0.0	267.0	267.0	213.8
2003	397.7	346.8	1,071	0	371.4	1.0	0.0	23.1	394.5	0.0	311.3	311.3	83.2
2004	454.2	395.9	1,071	0	424.0	1.0	0.0	23.1	447.1	0.0	355.5	355.5	91.5
2005	510.8	445.0	1,071	0	476.6	1.0	0.0	23.1	499.7	0.0	399.8	399.8	99.9
2006	567.3	494.1	1,071	0	529.2	1.0	0.0	23.1	552.2	0.0	444.0	444.0	108.2
2007	623.8	543.2	1,071	0	581.8	1.0	0.0	23.1	604.8	0.0	488.3	488.3	116.5
2008	680.4	592.3	1,071	0	634.3	1.0	0.0	23.1	657.4	0.0	532.5	532.5	124.9
2009	736.9	641.4	1,071	0	686.9	1.0	0.0	23.1	710.0	0.0	576.8	576.8	133.2
2010	793.4	690.5	1,071	0	739.5	1.0	0.0	23.1	762.6	0.0	621.0	621.0	141.5
2011	850.0	739.6	1,071	0	792.1	1.0	0.0	23.1	815.1	0.0	665.3	665.3	149.9
2012	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2013	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2014	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2015	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2016	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2017	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2018	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2019	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2020	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2021	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2022	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
2023	906.5	788.7	1,071	0	844.7	1.0	0.0	23.1	867.7	0.0	709.5	709.5	158.2
												FIRR (%)	**(0.2)**

AC = additional connection, FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A9.9: Total Project

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	Revenue (KN million)				Cost (KN million)			Net Benefit (KN million)
			From Water Sales	From New Connections	Meter Rental Income	Total Revenue	Invest-ments	O&M	Total Cost	
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	2,382.4	0.0	2,382.4	(2,382.4)
1996	0.0	0.0	0.0	0.0	0.0	0.0	3,521.0	0.0	3,521.0	(3,521.0)
1997	0.0	0.0	0.0	0.0	0.0	0.0	20,341.3	0.0	20,341.3	(20,341.3)
1998	0.0	0.0	0.0	0.0	0.0	0.0	8,240.2	0.0	8,240.2	(8,240.2)
1999	1,522.5	1,083.9	959.7	3,602.6	63.0	4,625.3	529.7	1,749.8	2,279.5	2,345.8
2000	2,013.8	1,650.1	1,684.8	917.7	103.1	2,705.6	0.0	2,467.2	2,467.2	238.4
2001	2,307.8	1,937.3	2,000.2	725.3	149.5	2,875.1	0.0	2,827.7	2,827.7	47.4
2002	2,751.3	2,301.9	3,074.2	550.6	179.0	3,803.8	0.0	3,005.6	3,005.6	798.2
2003	3,096.5	2,596.2	3,488.9	190.5	184.7	3,864.1	0.0	3,621.2	3,621.2	242.9
2004	3,441.7	2,890.5	3,903.6	190.5	190.3	4,284.4	0.0	4,236.9	4,236.9	47.6
2005	3,786.9	3,184.7	4,318.2	190.5	196.0	4,704.8	0.0	4,852.5	4,852.5	(147.8)
2006	4,132.1	3,479.0	4,732.9	190.5	201.6	5,125.1	0.0	5,468.2	5,468.2	(343.1)
2007	4,477.3	3,773.3	5,147.6	190.5	207.3	5,545.4	0.0	6,083.8	6,083.8	(538.4)
2008	4,822.5	4,067.6	5,562.3	190.5	212.9	5,965.7	0.0	6,699.5	6,699.5	(733.7)
2009	5,167.7	4,361.8	5,976.9	190.5	218.6	6,386.1	0.0	7,315.1	7,315.1	(929.0)
2010	5,512.9	4,656.1	6,391.6	190.5	224.2	6,806.4	0.0	7,930.8	7,930.8	(1,124.3)
2011	5,858.1	4,950.4	6,806.3	190.5	229.9	7,226.7	0.0	8,546.4	8,546.4	(1,319.7)
2012	6,203.3	5,244.7	7,221.0	190.5	235.6	7,647.1	13,236.4	9,162.1	22,398.4	(14,751.4)
2013	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2014	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2015	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2016	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2017	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2018	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2019	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2020	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2021	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2022	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
2023	6,203.3	5,244.7	7,221.0	0.0	235.6	7,456.5	0.0	9,162.1	9,162.1	(1,705.5)
									FIRR (%)	**negative**

FIRR = financial internal rate of return, KN = kip, m^3 = cubic meter, O&M = operation and maintenance.

Sources: Water Supply Authority. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

ECONOMIC ANALYSIS

1. This economic analysis examines the Project's contribution to the Lao People's Democratic Republic. It considers the Project's economic costs and benefits during the construction period and a 25-year operating period. All the systems are new and replace water previously provided by private household wells and river and spring sources. Costs and benefits are valued using a domestic price numeraire. This adjusts border price equivalent values to their equivalent domestic prices and entails the application of shadow price adjustments to convert the estimated financial costs to their equivalents. The shadow exchange rate factor is set at 1.25.

2. Revenues and costs have been further converted to 2002 constant prices using average gross domestic product deflator calculations. Data for the economic analysis have been taken from the draft benefit monitoring and evaluation report for 2002 by the Water Supply Authority (WASA), the Asian Development Bank's (ADB) project completion report (PCR) and project preparatory technical assistance report, the consultant's PCR, and in some cases the findings of the Operations Evaluation Mission (OEM).[1]

A. Assumptions Made

3. The calculations assume that the provincial water utilities are managed in such a way that the design capacity of the systems can be fully utilized by 2012, which particularly in the case of the four towns with fuel- or electricity-operated plants means a significant increase in the number of new house connections compared with previous years, as well as longer operating times for mechanical equipment and more efficient running of the slow sand filters.

4. The economic cost of 1 cubic meter (m^3) of water supplied by the Project is assumed to be equivalent to the tariff for 1 m^3 as determined by the provincial governors, the annualized value per 1 m^3 of a house connection, and a value that lies midway between the economic cost of the water without the Project and the tariff. In the absence of data to support the calculation of a demand curve, the calculations assume that the value is 0.5 times the difference between the economic cost of the water without the Project and the tariff. The operation and maintenance (O&M) costs are assumed to rise in proportion with the increase in water production from 2002 on. The OEM corroborates that the economic life of the Project can be assumed to be 25 years

[1] WASA. 2003. *Benefit Monitoring and Evaluation Report.* Vientiane; ADB. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; ADB. 1993. *Technical Assistance to the Lao People's Democratic Republic for Northern Provincial Towns Water Supply Development.* Manila; and BETURE SETAME of France in association with SEATEC of Thailand and SK Consultant of Lao People's Democratic Republic. 1998. Northern Provincial Towns Water Supply and Sanitation Project, *Project Completion Report.* Vientiane. The draft benefit monitoring and evaluation report for 2002 by WASA provided data for 1999–2002 on total water production, total water consumption (cubic meters of water sold and revenue), proportion of nonaccounted-for-water in 2002, population served, average tariff, and operation and maintenance costs. For a few subprojects for which the figures were missing in the benefit monitoring and evaluation report, the OEM findings were used. The maximum water production and the maximum population served by the system (to be reached by 2012) were derived from the consultants' PCR. In three cases, the figures have been adjusted downward on the basis of the OEM's findings. In Phonsavanh, the spring sources deliver less water than anticipated at the design stage because of ecological changes in the area. In Xam Nua, water needs to be shared with agricultural users in the dry season. In Pakxan, only five of the seven wells have been operational for the last years. The 1993 socioeconomic survey, part of the project preparatory technical assistance, is the source of the estimates of average liters of water consumption per capita per day in the base year, the average size of households, the estimate of average annual household income, and the average time taken per household to collect water from wells and rivers (between 30 and 80 minutes per day). The shadow rate of unskilled labor used was also derived from the PCR.

as reflected in the PCR, rather than 35 as in the report and recommendation of the President (RRP). This is mainly due to inefficient O&M of the assets created. In line with observations by the OEM, the life of mechanical equipment, such as mechanical treatment plants and pumping equipment, was set at around 12 years, and will thus require replacement around 2012. The RRP assumed rehabilitation of the equipment after 15 years.

5. Almost all households either had wells in their yards or in the vicinity, and the economic calculations assume that households can continue to use such wells and can dig new wells through the use of their own labor and without capital investment. The calculations, therefore, assume that the economic cost of this water is equivalent to the value of the time lost due to construction and maintenance of the wells (at one hour per week per household) and to collection of the water (only a few households in a few places used pumps). The value of time lost is obtained by multiplying the hours per day spent on water collection by the shadow rate of labor costs (estimated to be equivalent to 0.80 of the household income per household member). Given that most of the household income is derived from agriculture and trade, an 8-hour, 7 days per week work week was assumed to calculate the hourly cost of daily water collection. In three project locations, households bought some water (usually untreated) from vendors during the dry season, and these costs have been included in the analysis as economic costs.

B. Economic Costs

6. The economic costs of the Project are the incremental capital and O&M costs. Costs associated with the disposal of wastewater are not included, as these were not ascertained. The opportunity cost of water is not considered. In Xam Nua, the use of water for agricultural purposes has been taken into account in the calculation of the maximum water supply.

7. The economic costs of capital works are computed from the actual disbursements for the Project during the implementation period with the adjustment that tradable inputs are valued using a shadow exchange rate factor of 1.25 as in the PCR. Of the O&M costs, 70% was regarded as tradable input, with the remainder (average personnel costs) taken as nontradable. A labor adjustment factor of 2.0 was included to account for the economic cost of scarce highly skilled labor, assumed to be equivalent to around half of the personnel costs for O&M. Other labor was rated at 1.0.

8. The costs of wastewater drainage and the required improved septic tanks are not included in this analysis, neither are the health costs of such wastewater disposal in the vicinity of houses. The lack of inclusion of the costs of better wastewater disposal is assumed to some extent to compensate for the lack of inclusion of the land price benefit because of the water supply system.

C. Economic Benefits

1. Nonincremental Output

9. Project beneficiaries will no longer incur the costs associated with securing water from shallow wells, springs, or rivers or with purchasing water from vendors. The resource cost savings are estimated by multiplying the quantity of water consumed without the Project by the average economic supply price if the Project were not implemented. The average economic supply price comprises the costs of collecting and storing water and the cost of buying water.

This is calculated by multiplying the economic value of the time used for collection and storage and adding the cost of water bought from vendors (in Houayxay, Pakxan, and Phonhong only).

2. Incremental Output

10. The benefit of the additional water made available by the Project is equivalent to the willingness to pay for an improved water supply as reflected in the water tariffs and connection charges. In the analysis, this is equivalent to the amount of water households in the service areas consumed beyond what they would have consumed in the base year without the Project, multiplied by a value equivalent to the tariff, the annualized charge of house connection, and half of the difference between the economic value of nonincremental water and the tariff.

3. Reduction of Nonrevenue Water

11. As noted by the PCR, anecdotal evidence obtained by the OEM suggests that on average, 3% of the water is stolen. An adjustment factor on this order (3% of water produced times the value of the tariff) has been applied to the gross benefit stream to compensate for this small loss that benefits consumers even though it is not paid for.

4. Benefits Not Evaluated

12. The RRP had anticipated economic benefits from reduced medical costs and more working days because of better health, savings on fuelwood for boiling water, and more water for kitchen gardening. The OEM deems the health effects to be modest in an economic sense, given that the Project did not provide safe potable water and people boil the water before drinking it. Therefore, the economic benefits related to health effects will be low and have not been included separately, other than through the willingness to pay for incremental supplies. Health effects from better hygiene resulting from more washing are also not quantified in economic terms, given that this effect may be offset by a possible negative effect caused by more wastewater around the house. As the water still needs to be boiled for drinking, benefits from reduced use of fuel and time saved from no longer needing to collect fuelwood for boiling water have not arisen, and were therefore also not included separately in the analysis. The OEM did not corroborate kitchen gardening benefits from the increased availability of water, thus these were also not counted separately. Finally, the increase in property values in the service area has not been included in the economic analysis, although anecdotal evidence suggests a doubling of values in some places compared with land not in the service area. All these benefits were also not taken into account separately in the PCR's economic analysis, but are deemed to be sufficiently reflected in the economic price of incremental supply, set at a value that adds (i) half of the difference between the economic cost of nonincremental supply and the tariff, (ii) the tariff, and (iii) the annualized cost of the connection charge.

D. Economic Internal Rate of Return

13. Economic internal rates of return (EIRRs) for the seven towns and for the Project as a whole are calculated in Tables A9.1–A9.8. Whereas the aggregate EIRR for the Project was 18.2% in the PCR some 3 years ago, it is negative in the present analysis. The EIRR for the Project was not calculated in the RRP, but in the report of the feasibility study, four of the seven towns had EIRRs below the cutoff value of 12% (between 6.8% and 11.8%). Only Phonhong, Phonsavanh, and Xam Nua had good EIRRs, at 13.8%, 13.8%, and 12.7% respectively.

14. The main reason for the much lower EIRRs lies in the methodology used.[2] The PCR arrives at its high EIRR based on the assumption that between 60% and 80% of the water delivered by the system is nonincremental, and that the economic value of this water can be rated at the economic cost of well or river water before the system was introduced, multiplied by a factor of 1.1 each year. Similarly, the incremental water supply, assumed to be between 20% and 40% of total supply, was valued at the tariff and increased by a factor of 1.1 each year. These assumptions, particularly the escalation factors, overestimate the economic value of the water and are not used here. Instead the calculations assume that in the absence of the Project, all town inhabitants could continue to obtain the amounts of untreated water that they obtained from their own wells or from rivers in the neighborhood before the Project. Nonincremental supply for every user of the piped water system is then equivalent to the per capita use of well or river water in 1993 (between 20 and 60 liters per capita per day), kept constant throughout the economic life of the Project, and valued at its economic cost, without the annual increase by a factor of 1.1. Similarly, the incremental water delivered is rated at an economic value that does not include the annual incorporation of a factor of 1.1. In addition, there are some differences in O&M costs, as the PCR did not incorporate the effect of rehabilitation of some of the equipment (in four towns). The main reason for the negative EIRR is the low tariff. Indeed, the 1993 project feasibility study assumed a tariff equivalent to around $0.28 per m^3, about half of that achieved in 2002.

15. The Project is not economically viable under these circumstances except in Houayxay. Even most systems with low O&M costs, such as those based on slow sand filter systems, are not economically advantageous. The main reason is that they do not supply potable water, which means that the benefits of not having to boil or otherwise treat the water are lost. Health effects are therefore also forgone, limiting the willingness to pay. The cost of collecting the water from wells and rivers was low in many towns, which had extremely low income per capita. In Houayxay, the economic cost of water is higher, whereas the O&M costs of the water utility are lower than in other towns with a high economic cost of water, such as Phonhong and Pakxan.

[2] Production capacity, although estimated in the PCR at 22,041 m^3, was estimated at 17,228 m^3 in the economic analysis, achieved in 2012 and continued until 2022. This is not much different from the adjusted value of 16,995 m^3 used in this analysis.

Table A10.1: Houayxay

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified)								Resource Cost (KN million)					NEB (KN million)
				NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Invest-ments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	260.5	0.0	45.6	0.0	306.1	(306.1)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	385.0	0.0	67.4	0.0	452.4	(452.4)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	2,224.2	0.0	389.2	0.0	2,613.4	(2,613.4)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	901.0	0.0	157.7	0.0	1,058.7	(1,058.7)
1999	276.3	93.8	4,614	85.9	331.9	1,446	151	7.9	22.1	12.0	366.0	60.1	156.2	37.9	15.6	269.8	96.1
2000	382.5	322.6	5,500	102.4	395.6	859	52	220.2	531.6	9.9	937.1	0.0	273.0	47.8	31.4	352.2	584.8
2001	471.0	353.2	6,600	122.9	474.8	737	57	230.3	543.1	10.4	1,028.2	0.0	113.0	19.8	14.8	147.5	880.7
2002	525.9	447.0	7,838	145.9	563.8	926	54	301.1	737.3	14.6	1,315.7	0.0	416.0	72.8	61.3	550.1	765.6
2003	542.7	461.2	7,883	146.7	567.1	926	52	314.5	769.8	15.1	1,351.9	0.0	429.3	75.1	70.7	575.2	776.7
2004	559.5	475.5	7,928	147.6	570.3	926	51	327.9	802.2	15.5	1,388.1	0.0	442.6	77.5	80.9	601.0	787.1
2005	576.3	489.8	7,974	148.4	573.6	926	50	341.4	834.7	16.0	1,424.3	0.0	455.9	79.8	92.1	627.8	796.5
2006	593.1	504.1	8,019	149.3	576.8	926	49	354.8	867.2	16.5	1,460.4	0.0	469.2	82.1	104.2	655.5	804.9
2007	609.9	518.4	8,064	150.1	580.1	926	48	368.3	899.6	16.9	1,496.6	0.0	482.5	84.4	117.4	684.3	812.3
2008	626.7	532.7	8,109	151.0	583.3	926	47	381.7	932.1	17.4	1,532.8	0.0	495.8	86.8	131.6	714.1	818.7
2009	643.5	546.9	8,154	151.8	586.6	926	46	395.1	964.5	17.9	1,568.9	0.0	509.1	89.1	147.0	745.1	823.8
2010	660.3	561.2	8,200	152.6	589.8	926	45	408.6	996.9	18.3	1,605.1	0.0	522.4	91.4	163.6	777.3	827.8
2011	677.1	575.5	8,245	153.5	593.1	926	44	422.0	1,029.4	18.8	1,641.2	0.0	535.6	93.7	181.5	810.8	830.4
2012	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	200.7	845.7	831.6
2013	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	216.3	861.3	816.1
2014	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	232.6	877.6	799.8
2015	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	249.7	894.7	782.7
2016	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	267.7	912.7	764.7
2017	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	286.5	931.5	745.8
2018	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	306.4	951.4	726.0
2019	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	327.2	972.2	705.2
2020	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	349.0	994.0	683.4
2021	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	371.9	1,016.9	660.4
2022	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	396.0	1,041.0	636.3
2023	693.9	589.8	8,290	154.3	596.3	926	43	435.5	1,061.8	19.3	1,677.4	0.0	548.9	96.1	421.3	1,066.3	611.0
Total	**15,470.9**	**12,959.3**		**3,659.9**	**14,142.4**			**9,299.4**	**22,671.6**	**430.6**	**37,244.7**	**3,830.9**	**11,887.9**	**2,750.8**	**4,837.2**	**23,306.8**	**13,937.9**

Cost of Water Consumption per Capita per Year	KN	71,932	**EIRR** (%)	**13.08**
Economic Cost/m^3 of Nonincremental Water	KN	3,864		

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A10.2: Pakxan

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified)								Resource Cost (KN million)					NEB (KN million)
				NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Invest-ments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	345.6	0.0	60.5	0.0	406.1	(406.1)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	510.8	0.0	89.4	0.0	600.2	(600.2)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	2,951.1	0.0	516.4	0.0	3,467.5	(3,467.5)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	1,195.5	0.0	209.2	0.0	1,404.7	(1,404.7)
1999	262.8	249.0	5,635	156.3	449.0	718	102	92.7	175.9	5.7	630.5	59.5	477.6	94.0	47.8	678.9	(48.4)
2000	420.2	363.5	7,446	206.6	593.2	1,158	92	157.0	330.9	14.6	938.7	0.0	596.6	104.4	68.6	769.7	169.0
2001	436.7	410.9	8,556	237.3	681.7	1,292	94	173.5	377.6	16.9	1,076.2	0.0	668.5	117.0	87.4	872.9	203.3
2002	532.1	472.5	9,048	251.0	720.9	1,208	86	221.6	471.1	19.3	1,211.3	0.0	441.5	77.3	65.0	583.8	627.5
2003	580.3	515.5	9,312	258.3	741.9	1,208	82	257.2	545.7	21.0	1,308.6	0.0	481.5	84.3	79.3	645.0	663.6
2004	628.4	558.5	9,575	265.6	762.9	1,208	77	292.9	620.1	22.8	1,405.8	0.0	521.4	91.2	95.4	708.0	697.7
2005	676.6	601.4	9,839	272.9	783.9	1,208	74	328.5	694.4	24.5	1,502.8	0.0	561.4	98.2	113.4	773.0	729.8
2006	724.7	644.4	10,102	280.2	804.9	1,208	71	364.2	768.7	26.3	1,599.8	0.0	601.3	105.2	133.6	840.1	759.7
2007	772.9	687.4	10,366	287.5	825.9	1,208	68	399.8	842.8	28.0	1,696.7	0.0	641.3	112.2	156.0	909.5	787.3
2008	821.0	730.3	10,629	294.8	846.8	1,208	66	435.5	917.0	29.8	1,793.6	0.0	681.2	119.2	180.8	981.2	812.4
2009	869.2	773.3	10,893	302.2	867.8	1,208	64	471.1	991.0	31.5	1,890.4	0.0	721.2	126.2	208.2	1,055.5	834.8
2010	917.4	816.2	11,156	309.5	888.8	1,208	62	506.8	1,065.1	33.2	1,987.2	0.0	761.1	133.2	238.3	1,132.6	854.6
2011	965.5	859.2	11,420	316.8	909.8	1,208	60	542.4	1,139.1	35.0	2,083.9	0.0	801.1	140.2	271.4	1,212.6	871.3
2012	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	2,013.8	841.0	499.6	307.6	3,662.0	(1,481.3)
2013	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	331.3	1,319.5	861.1
2014	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	356.3	1,344.5	836.1
2015	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	382.5	1,370.7	809.9
2016	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	410.1	1,398.3	782.4
2017	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	439.0	1,427.2	753.4
2018	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	469.4	1,457.5	723.1
2019	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	501.2	1,489.4	691.2
2020	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	534.7	1,522.9	657.7
2021	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	569.8	1,558.0	622.6
2022	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	606.8	1,594.9	585.7
2023	1,013.7	902.2	11,683	324.1	930.8	1,208	58	578.1	1,213.1	36.7	2,180.6	0.0	841.0	147.2	645.5	1,633.7	546.9
Total	**20,771.9**	**18,508.0**		**7,328.1**	**21,047.3**			**11,179.9**	**23,496.2**	**749.4**	**45,292.8**	**7,076.3**	**18,047.7**	**4,396.7**	**7,299.3**	**36,820.0**	**8,472.8**

Cost of Water Consumption per Capita per Year	KN	79,673	**EIRR** (%)	**6.76**
Economic Cost/m^3 of Nonincremental Water	KN	2,872		

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A10.3: Phongsali

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified)								Resource Cost (KN million)					NEB (KN million)
				NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Invest-ments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	306.9	0.0	53.7	0.0	360.6	(360.6)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	453.6	0.0	79.4	0.0	533.0	(533.0)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	2,620.5	0.0	458.6	0.0	3,079.1	(3,079.1)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	1,061.6	0.0	185.8	0.0	1,247.3	(1,247.3)
1999	19.3	13.1	3,400	60.8	138.1	2,694	1,455	(47.7)	(187.9)	1.6	(48.2)	70.9	131.2	35.4	13.1	250.5	(298.7)
2000	40.1	31.0	3,442	61.6	139.8	2,632	621	(30.5)	(93.8)	3.2	49.2	0.0	149.6	26.2	17.2	192.9	(143.8)
2001	54.0	41.8	3,509	62.8	142.5	2,757	470	(21.0)	(62.7)	4.5	84.3	0.0	159.9	28.0	20.9	208.8	(124.5)
2002	68.3	52.8	3,765	67.3	152.9	2,004	399	(14.5)	(36.8)	4.1	120.2	0.0	191.1	33.4	28.1	252.7	(132.5)
2003	108.8	84.0	3,965	70.9	161.0	2,004	264	13.1	31.4	6.5	199.0	0.0	304.4	53.3	50.1	407.7	(208.8)
2004	149.2	115.1	4,164	74.5	169.1	2,004	203	40.6	95.1	9.0	273.2	0.0	417.6	73.1	76.4	567.1	(293.9)
2005	189.7	146.3	4,364	78.0	177.2	2,004	167	68.2	157.2	11.4	345.9	0.0	530.9	92.9	107.2	731.0	(385.2)
2006	230.2	177.4	4,563	81.6	185.4	2,004	144	95.8	218.5	13.8	417.7	0.0	644.1	112.7	143.1	899.9	(482.2)
2007	270.7	208.5	4,763	85.2	193.5	2,004	128	123.4	279.5	16.3	489.2	0.0	757.4	132.5	184.2	1,074.1	(584.9)
2008	311.1	239.7	4,962	88.7	201.6	2,004	116	150.9	340.1	18.7	560.4	0.0	870.6	152.4	231.1	1,254.0	(693.7)
2009	351.6	270.8	5,162	92.3	209.7	2,004	107	178.5	400.6	21.1	631.4	0.0	983.9	172.2	284.0	1,440.1	(808.6)
2010	392.1	302.0	5,361	95.9	217.8	2,004	99	206.1	461.0	23.6	702.3	0.0	1,097.1	192.0	343.5	1,632.6	(930.3)
2011	432.6	333.1	5,561	99.4	225.9	2,004	93	233.6	521.3	26.0	773.1	0.0	1,210.4	211.8	410.0	1,832.2	(1,059.1)
2012	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	2,416.6	1,323.6	654.5	484.0	4,878.7	(4,034.8)
2013	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	521.5	2,076.7	(1,232.8)
2014	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	560.8	2,116.0	(1,272.1)
2015	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	602.1	2,157.3	(1,313.4)
2016	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	645.4	2,200.7	(1,356.7)
2017	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	690.9	2,246.2	(1,402.2)
2018	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	738.7	2,293.9	(1,450.0)
2019	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	788.9	2,344.1	(1,500.2)
2020	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	841.5	2,396.8	(1,552.9)
2021	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	896.9	2,452.1	(1,608.2)
2022	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	954.9	2,510.2	(1,666.3)
2023	473.0	364.2	5,760	103.0	234.0	2,004	89	261.2	581.5	28.4	843.9	0.0	1,323.6	231.6	1,015.9	2,571.2	(1,727.3)
Total	**8,294.2**	**6,386.4**		**2,255.3**	**5,122.2**			**4,131.1**	**9,101.4**	**501.0**	**14,724.7**	**6,930.0**	**23,331.5**	**5,295.8**	**10,650.5**	**46,207.8**	**(31,483.1)**

Cost of Water Consumption per Capita per Year	KN	40,621	**EIRR** (%)	**negative**
Economic Cost/m^3 of Nonincremental Water	KN	2,271		

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A10.4: Phonhong

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified)								Resource Cost (KN million)					NEB (KN million)
				NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Invest-ments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	383.5	0.0	67.1	0.0	450.6	(450.6)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	566.8	0.0	99.2	0.0	665.9	(665.9)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	3,274.2	0.0	573.0	0.0	3,847.2	(3,847.2)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	1,326.4	0.0	232.1	0.0	1,558.5	(1,558.5)
1999	101.6	89.2	4,068	86.1	280.8	507	177	3.1	6.4	1.5	288.7	88.5	161.0	43.7	16.1	309.3	(20.6)
2000	140.7	122.9	5,500	116.4	379.6	1,287	173	6.5	15.9	5.4	401.0	0.0	338.1	59.2	38.9	436.2	(35.2)
2001	185.7	162.0	6,600	139.7	455.5	1,187	158	22.2	52.9	6.6	515.1	0.0	516.3	90.4	67.5	674.2	(159.1)
2002	218.9	190.4	7,943	168.2	548.2	1,076	161	22.3	51.9	7.1	607.1	0.0	692.5	121.2	102.0	915.7	(308.6)
2003	275.8	240.0	8,108	171.6	559.6	1,076	131	68.3	157.1	8.9	725.5	0.0	872.7	152.7	143.7	1,169.1	(443.6)
2004	332.8	289.5	8,273	175.1	571.0	1,076	111	114.4	260.6	10.7	842.3	0.0	1,052.9	184.3	192.6	1,429.7	(587.4)
2005	389.7	339.1	8,438	178.6	582.3	1,076	96	160.4	363.3	12.6	958.2	0.0	1,233.1	215.8	249.1	1,698.0	(739.8)
2006	446.7	388.6	8,603	182.1	593.7	1,076	86	206.5	465.4	14.4	1,073.5	0.0	1,413.3	247.3	313.9	1,974.6	(901.0)
2007	503.6	438.2	8,768	185.6	605.1	1,076	77	252.6	567.1	16.3	1,188.5	0.0	1,593.5	278.9	387.6	2,260.0	(1,071.5)
2008	560.6	487.7	8,932	189.1	616.5	1,076	71	298.6	668.6	18.1	1,303.1	0.0	1,773.7	310.4	470.7	2,554.8	(1,251.7)
2009	617.5	537.3	9,097	192.6	627.9	1,076	66	344.7	769.8	19.9	1,417.6	0.0	1,953.9	341.9	564.0	2,859.9	(1,442.2)
2010	674.5	586.8	9,262	196.1	639.2	1,076	61	390.7	871.0	21.8	1,532.0	0.0	2,134.1	373.5	668.2	3,175.7	(1,643.8)
2011	731.4	636.4	9,427	199.6	650.6	1,076	57	436.8	972.0	23.6	1,646.2	0.0	2,314.3	405.0	784.0	3,503.3	(1,857.0)
2012	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	4,403.0	2,494.5	1,207.1	912.2	9,016.8	(7,256.4)
2013	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	982.8	3,913.8	(2,153.4)
2014	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,056.9	3,987.9	(2,227.5)
2015	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,134.7	4,065.7	(2,305.3)
2016	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,216.3	4,147.4	(2,386.9)
2017	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,302.1	4,233.1	(2,472.7)
2018	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,392.1	4,323.2	(2,562.8)
2019	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,486.7	4,417.7	(2,657.3)
2020	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,586.0	4,517.0	(2,756.6)
2021	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,690.2	4,621.2	(2,860.8)
2022	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,799.7	4,730.7	(2,970.3)
2023	788.4	685.9	9,592	203.1	662.0	1,076	54	482.8	1,072.9	25.4	1,760.4	0.0	2,494.5	436.5	1,914.6	4,845.6	(3,085.2)
Total	**14,640.3**	**12,738.9**		**4,617.7**	**15,054.2**			**8,121.2**	**18,097.3**	**472.4**	**33,623.8**	**10,042.4**	**45,983.3**	**9,804.5**	**20,472.5**	**86,302.7**	**(52,678.9)**

Cost of Water Consumption per Capita per Year	KN	69,017	**EIRR** (%) **negative**
Economic Cost/m^3 of Nonincremental Water	KN	3,260	

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A10.5: Phonsavanh[a]

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified) NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Resource Cost (KN million) Investments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	NEB (KN million)
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	386.3	0.0	67.6	0.0	453.9	(453.9)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	570.9	0.0	99.9	0.0	670.8	(670.8)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	3,298.0	0.0	577.1	0.0	3,875.1	(3,875.1)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	1,336.0	0.0	233.8	0.0	1,569.8	(1,569.8)
1999	453.0	307.1	8,352	155.5	250.5	819	143	151.6	205.8	11.1	467.4	89.2	107.3	34.4	10.7	241.6	225.8
2000	516.0	395.0	9,350	174.1	280.4	629	124	220.9	274.9	9.7	565.1	0.0	472.9	82.8	54.4	610.0	(44.9)
2001	611.0	463.0	10,731	199.8	321.8	706	122	263.2	337.0	12.9	671.7	0.0	616.6	107.9	80.6	805.1	(133.3)
2002	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	64.6	580.3	447.3
2003	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	72.3	587.9	439.7
2004	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	80.3	595.9	431.7
2005	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	88.7	604.3	423.3
2006	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	97.5	613.1	414.5
2007	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	106.7	622.4	405.2
2008	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	116.5	632.1	395.5
2009	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	126.7	642.3	385.3
2010	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	137.4	653.0	374.6
2011	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	148.7	664.3	363.3
2012	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	160.5	676.1	351.5
2013	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	172.9	688.5	339.1
2014	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	185.9	701.5	326.1
2015	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	199.6	715.2	312.4
2016	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	214.0	729.6	298.0
2017	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	229.1	744.7	282.9
2018	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	244.9	760.5	267.1
2019	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	261.5	777.2	250.4
2020	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	279.0	794.6	233.0
2021	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	297.3	813.0	214.6
2022	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	316.6	832.2	195.4
2023	751.0	573.6	11,242	209.3	337.2	1,756	103	364.4	650.9	39.6	1,027.6	0.0	438.8	76.8	336.8	852.4	175.2
Total	**18,102.0**	**13,785.1**		**5,133.2**	**8,270.2**			**8,651.9**	**15,137.0**	**904.2**	**24,311.4**	**5,680.3**	**10,850.9**	**2,893.0**	**4,083.0**	**23,507.2**	**804.1**

Cost of Water Consumption per Capita per Year	KN	29,991	**EIRR** (%)	**0.85**
Economic Cost/m^3 of Nonincremental Water	KN	1,611		

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

[a] Due to source problems, water is not assumed to increase further.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A10.6: Sayaburi

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified)								Resource Cost (KN million)					NEB (KN million)
				NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Invest-ments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	424.1	0.0	74.2	0.0	498.4	(498.4)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	626.8	0.0	109.7	0.0	736.5	(736.5)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	3,621.4	0.0	633.7	0.0	4,255.1	(4,255.1)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	1,467.0	0.0	256.7	0.0	1,723.7	(1,723.7)
1999	163.6	133.8	6,618	123.2	156.6	1,588	226	10.6	17.5	7.8	181.9	97.9	380.9	83.8	38.1	600.8	(418.8)
2000	234.6	205.9	4,854	90.4	114.9	1,755	108	115.6	187.3	12.4	314.5	0.0	323.1	56.5	37.2	416.8	(102.3)
2001	234.3	214.9	8,442	157.1	199.8	1,864	179	57.8	100.9	13.1	313.8	0.0	355.3	62.2	46.5	463.9	(150.2)
2002	313.9	267.8	9,096	169.3	215.3	1,690	155	98.5	161.0	15.9	392.2	0.0	558.6	97.7	82.3	738.6	(346.3)
2003	440.2	375.0	10,091	187.8	238.8	1,690	123	187.2	300.1	22.3	561.3	0.0	783.3	137.1	129.0	1,049.3	(488.0)
2004	566.5	482.3	11,085	206.3	262.3	1,690	105	275.9	437.5	28.7	728.5	0.0	1,008.0	176.4	184.3	1,368.7	(640.2)
2005	692.8	589.5	12,080	224.9	285.9	1,690	93	364.7	574.0	35.1	895.0	0.0	1,232.7	215.7	249.0	1,697.4	(802.4)
2006	819.1	696.8	13,074	243.4	309.4	1,690	86	453.4	710.1	41.5	1,061.0	0.0	1,457.4	255.0	323.7	2,036.2	(975.1)
2007	945.4	804.0	14,069	261.9	332.9	1,690	80	542.2	845.9	47.9	1,226.8	0.0	1,682.1	294.4	409.1	2,385.6	(1,158.8)
2008	1,071.6	911.3	15,063	280.4	356.5	1,690	75	630.9	981.6	54.3	1,392.4	0.0	1,906.8	333.7	506.1	2,746.6	(1,354.1)
2009	1,197.9	1,018.5	16,058	298.9	380.0	1,690	72	719.6	1,117.2	60.7	1,557.9	0.0	2,131.5	373.0	615.3	3,119.8	(1,561.9)
2010	1,324.2	1,125.8	17,052	317.4	403.5	1,690	69	808.4	1,252.6	67.1	1,723.3	0.0	2,356.2	412.3	737.7	3,506.3	(1,783.0)
2011	1,450.5	1,233.0	18,047	335.9	427.1	1,690	67	897.1	1,388.1	73.5	1,888.7	0.0	2,580.9	451.7	874.3	3,906.9	(2,018.2)
2012	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	4,403.0	2,805.6	1,261.5	1,026.0	9,496.2	(7,442.2)
2013	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,105.4	4,402.0	(2,348.0)
2014	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,188.7	4,485.3	(2,431.3)
2015	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,276.2	4,572.8	(2,518.8)
2016	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,368.0	4,664.7	(2,610.7)
2017	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,464.5	4,761.1	(2,707.1)
2018	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,565.8	4,862.4	(2,808.4)
2019	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,672.1	4,968.7	(2,914.8)
2020	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,783.8	5,080.4	(3,026.4)
2021	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	1,901.0	5,197.7	(3,143.7)
2022	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	2,024.1	5,320.8	(3,266.8)
2023	1,576.8	1,340.3	19,041	354.4	450.6	1,690	65	985.8	1,523.4	79.9	2,054.0	0.0	2,805.6	491.0	2,153.4	5,450.0	(3,396.1)
Total	**28,376.3**	**24,142.1**		**7,150.4**	**9,090.2**			**16,991.7**	**26,354.9**	**1,439.9**	**36,885.0**	**10,640.3**	**50,424.3**	**10,686.3**	**22,761.7**	**94,512.6**	**(57,627.6)**

Cost of Water Consumption per Capita per Year	KN	23,665	**EIRR** (%)	**negative**
Economic Cost/m^3 of Nonincremental Water	KN	1,271		

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A10.7: Xam Nua

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified)								Resource Cost (KN million)					NEB (KN million)
				NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Invest-ments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	275.5	0.0	48.2	0.0	323.7	(323.7)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	407.1	0.0	71.2	0.0	478.3	(478.3)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	2,351.9	0.0	411.6	0.0	2,763.5	(2,763.5)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	952.7	0.0	166.7	0.0	1,119.5	(1,119.5)
1999	246.0	198.0	8,154	151.8	140.6	510	248	46.2	48.0	3.8	192.3	63.6	246.4	54.2	24.6	388.9	(196.5)
2000	279.7	209.1	10,278	191.3	177.2	653	296	17.8	20.6	5.5	203.3	0.0	313.9	54.9	36.1	404.9	(201.6)
2001	315.0	291.6	10,932	203.5	188.5	599	226	88.1	93.5	5.7	287.7	0.0	398.1	69.7	52.1	519.8	(232.2)
2002	341.2	297.7	11,694	217.7	201.7	1,071	237	80.0	104.7	11.0	317.3	0.0	267.0	46.7	39.3	353.1	(35.8)
2003	397.7	346.8	11,694	217.7	201.7	1,071	203	129.1	164.6	12.8	379.0	0.0	311.3	54.5	51.3	417.0	(38.0)
2004	454.2	395.9	11,694	217.7	201.7	1,071	178	178.2	222.6	14.6	438.9	0.0	355.5	62.2	65.0	482.8	(43.9)
2005	510.8	445.0	11,694	217.7	201.7	1,071	158	227.3	279.5	16.4	497.6	0.0	399.8	70.0	80.8	550.5	(53.0)
2006	567.3	494.1	11,694	217.7	201.7	1,071	143	276.4	335.5	18.2	555.4	0.0	444.0	77.7	98.6	620.4	(65.0)
2007	623.8	543.2	11,694	217.7	201.7	1,071	130	325.5	390.9	20.0	612.6	0.0	488.3	85.4	118.8	692.5	(79.9)
2008	680.4	592.3	11,694	217.7	201.7	1,071	119	374.6	445.8	21.9	669.3	0.0	532.5	93.2	141.3	767.1	(97.7)
2009	736.9	641.4	11,694	217.7	201.7	1,071	110	423.7	500.4	23.7	725.7	0.0	576.8	100.9	166.5	844.2	(118.5)
2010	793.4	690.5	11,694	217.7	201.7	1,071	102	472.8	554.7	25.5	781.8	0.0	621.0	108.7	194.4	924.2	(142.4)
2011	850.0	739.6	11,694	217.7	201.7	1,071	95	521.9	608.7	27.3	837.7	0.0	665.3	116.4	225.4	1,007.1	(169.4)
2012	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	259.5	1,093.2	(199.8)
2013	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	279.5	1,113.3	(219.9)
2014	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	300.6	1,134.3	(240.9)
2015	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	322.7	1,156.5	(263.1)
2016	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	346.0	1,179.7	(286.3)
2017	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	370.4	1,204.1	(310.7)
2018	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	396.0	1,229.7	(336.3)
2019	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	422.9	1,256.6	(363.2)
2020	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	451.1	1,284.8	(391.4)
2021	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	480.8	1,314.5	(421.1)
2022	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	511.9	1,345.6	(452.2)
2023	906.5	788.7	11,694	217.7	201.7	1,071	89	571.0	662.6	29.1	893.4	0.0	709.5	124.2	544.6	1,378.3	(484.9)
Total	**17,674.6**	**15,349.1**		**5,335.7**	**4,943.0**			**10,013.5**	**11,720.4**	**555.8**	**17,219.1**	**4,050.8**	**14,134.5**	**3,182.4**	**5,980.2**	**27,347.9**	**(10,128.7)**

Cost of Water Consumption per Capita per Year KN 17,245

Economic Cost/m^3 of Nonincremental Water KN 1,071

EIRR (%) **negative**

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

Table A10.8: Total Project

(1993–2023; in constant 2002 prices)

Year	Total Water Produced ('000 m^3)	Total Water Consumed ('000 m^3)	PSS	Gross Benefit (KN million unless otherwise specified) NWQ ('000 m^3)	NB	AT (KN/m^3)	ACC (KN/m^3)	IWQ ('000 m^3)	IB	NL	Total Benefit	Resource Cost (KN million) Invest-ments	O&M + CNC	SERF-(1.25) RAC	LA	Total Cost	NEB (KN million)
1993	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	2,382.4	0.0	416.9	0.0	2,799.3	(2,799.3)
1996	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	3,521.0	0.0	616.2	0.0	4,137.2	(4,137.2)
1997	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	20,341.3	0.0	3,559.7	0.0	23,901.0	(23,901.0)
1998	0.0	0.0	0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	8,240.2	0.0	1,442.0	0.0	9,682.3	(9,682.3)
1999	1,522.5	1,083.9	40,841	819.6	1,747.4	1,183	172	264.3	287.8	43.4	2,078.6	529.7	1,660.6	383.3	166.1	2,739.7	(661.1)
2000	2,013.8	1,650.1	46,370	942.7	2,080.8	1,282	128	707.4	1,267.4	60.6	3,408.8	0.0	2,467.2	431.8	283.7	3,182.7	226.1
2001	2,307.8	1,937.3	55,370	1,123.1	2,464.6	1,306	131	814.2	1,442.2	70.1	3,977.0	0.0	2,827.7	494.8	369.7	3,692.3	284.7
2002	2,751.3	2,301.9	60,626	1,228.7	2,739.9	1,390	120	1,073.2	2,140.1	111.5	4,991.5	0.0	3,005.6	526.0	442.7	3,974.2	1,017.2
2003	3,096.5	2,596.2	62,294	1,262.4	2,807.2	1,390	110	1,333.8	2,619.5	126.2	5,552.8	0.0	3,621.2	633.7	596.2	4,851.2	701.7
2004	3,441.7	2,890.5	63,961	1,296.1	2,874.4	1,390	101	1,594.4	3,089.0	140.9	6,104.4	0.0	4,236.9	741.5	774.9	5,753.2	351.2
2005	3,786.9	3,184.7	65,629	1,329.8	2,941.7	1,390	94	1,854.9	3,554.0	155.6	6,651.3	0.0	4,852.5	849.2	980.3	6,682.1	(30.8)
2006	4,132.1	3,479.0	67,296	1,363.6	3,009.0	1,390	88	2,115.5	4,016.2	170.3	7,195.5	0.0	5,468.2	956.9	1,214.6	7,639.7	(444.2)
2007	4,477.3	3,773.3	68,964	1,397.3	3,076.2	1,390	83	2,376.0	4,476.7	185.0	7,738.0	0.0	6,083.8	1,064.7	1,479.8	8,628.3	(890.3)
2008	4,822.5	4,067.6	70,632	1,431.0	3,143.5	1,390	79	2,636.6	4,936.0	199.7	8,279.2	0.0	6,699.5	1,172.4	1,778.0	9,649.9	(1,370.7)
2009	5,167.7	4,361.8	72,299	1,464.7	3,210.8	1,390	76	2,897.1	5,394.4	214.4	8,819.6	0.0	7,315.1	1,280.1	2,111.6	10,706.9	(1,887.3)
2010	5,512.9	4,656.1	73,967	1,498.4	3,278.0	1,390	73	3,157.7	5,852.1	229.1	9,359.3	0.0	7,930.8	1,387.9	2,483.1	11,801.8	(2,442.5)
2011	5,858.1	4,950.4	75,634	1,532.2	3,345.3	1,390	70	3,418.2	6,309.4	243.8	9,898.5	0.0	8,546.4	1,495.6	2,895.2	12,937.2	(3,038.7)
2012	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	13,236.4	9,162.1	3,919.7	3,350.5	29,668.7	(19,231.4)
2013	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	3,609.7	14,375.1	(3,937.8)
2014	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	3,881.8	14,647.2	(4,209.9)
2015	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	4,167.5	14,932.9	(4,495.6)
2016	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	4,467.5	15,232.9	(4,795.6)
2017	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	4,782.5	15,547.9	(5,110.6)
2018	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	5,113.2	15,878.6	(5,441.4)
2019	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	5,460.5	16,225.9	(5,788.6)
2020	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	5,825.1	16,590.5	(6,153.3)
2021	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	6,208.0	16,973.4	(6,536.2)
2022	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	6,610.0	17,375.4	(6,938.2)
2023	6,203.3	5,244.7	77,302	1,565.9	3,412.6	1,390	67	3,678.8	6,766.2	258.5	10,437.3	0.0	9,162.1	1,603.4	7,032.2	17,797.6	(7,360.3)
Total	**123,330.2**	**103,869.0**		**35,480.1**	**77,669.4**			**68,388.8**	**126,578.8**	**5,053.2**	**209,301.5**	**48,251.0**	**174,660.1**	**39,009.4**	**76,084.4**	**338,005.0**	**(128,703.5)**

Cost of Water Consumption per Capita per Year KN 71,932

Economic Cost/m^3 of Nonincremental Water KN 2,132

EIRR (%) **negative**

ACC = annualized connection charge, AT = average tariff, EIRR = economic internal rate of return, IB = incremental benefit, IWQ = incremental water quantity, KN = kip, m^3 = cubic meter, LA = labor adjustment, NB = nonincremental benefit, NEB = net economic benefit, NL = nontechnical losses, NWQ = nonincremental water quantity, O&M + CNC = operation and maintenance + cost of new connections, PSS = population served by system, SERF-RAC = shadow exchange rate factor-related additional cost.

Sources: Asian Development Bank. 2000. *Project Completion Report on the Northern Provincial Towns Water Supply and Sanitation Project in the Lao People's Democratic Republic.* Manila; Operations Evaluation Mission; and provincial water utilities.

A COMPARISON OF DRINKING WATER STANDARDS

Selected Substance or Characteristic	Unit	World Health Organization			ECD (1980)		US EPA (1985)	CAN DWS (1994)	Recommended Project Standard for Bottled Water
		1993 Guideline Value	1971 Intl. Standard		Guideline Value	Maximum Admissible Concentration	Maximum Contaminant Level	Maximum Acceptable Concentration	
			Highest Desirable Level	Maximum Permissible Level					
Color	H/TCU	15 H	5 H	50 H	1 H	20 H	15 TCU	5 TCU[a]	5 TCU
Odor	TON	I	U			3	3	I	I
Taste	TON	I	U			2		I	I
Suspended Solids	mg/L				none				none
Turbidity	JTU/NTU	5 JTU[b]	5 JTU	25 JTU	0.4 JTU	4 JTU	0.5 NTU (95%)	1 NTU	1 NTU
pH		6–8.5	7–8.5	6.5–9.2	6.5–8.5	9.5	6.5–8.5	6.5–8.5	6.5–8.5
Temperature	ºC				12	25		15[a]	
Aluminum	mg/L	0.2			0.05	0.2		<0.1 (OG)	<0.1
Ammonium	mg/L				0.05	0.5			0.05
Arsenic	mg/L	0.05		0.05			0.03	0.025	0.025
Barium	mg/L				0.1		1.5	1.0	1.0
Boron	mg/L				1.0			5.0	1.0
Cadmium	mg/L	0.005		0.01		0.005	0.005	(0.005)	0.003
Calcium	mg/L		75	200	100				100
Chromium	mg/L	0.05				0.05	0.1	0.05	0.05
Chloride	mg/L	250	200	600	25		250	250[a]	250
Copper	mg/L		0.05		0.1		1. 0	1. 0	1.0
Cyanide	mg/L	0.1		0.05		0.05		0.2	0.05
Fluoride	mg/L	1.5		0.9–1.7		1.5		1.5 (1.2 +/- 0.2)[c]	1.5 (1.2 +/- 0.2)[c]
Hydrogen Sulfide	mg/L	ND				ND	0.05	0.05	ND
Iron	mg/L	0.3	0.1	1.0	0.05	0.2	0.3	0.3[a]	< 0.3
Lead	mg/L	0.05		0.1		0.05	0.02	0.01	0.01
Magnesium	mg/L		30	150	30	50			30
Manganese	mg/L	0.1	0.05	0.5	0.02	0.05	0.05	0.05[a]	0.05
Mercury	mg/L	0.001		0.001		0.001	0.002	0.001	0.001
Nickel	mg/L					0.05			0.05
Nitrates	mg/L	10 (as N)		45 (as NO_3)	25 (as NO_3)	50 (as NO_3)	10 (as N)	10 (as N)	< 10 (as N)
Nitrite	mg/L					0.1	1.0 (as N)	1.0 (as N)	1.0 (as N)
Potassium	mg/L				10	12			10

AO = aesthetic objective, ºC = degrees centigrade, CAN DWS = Canadian Drinking Water Standard, ECD = European Community Directive, H = hazen, I = inoffensive, JTU = Jackson turbidity unit, mg/L = milligram per liter, N = nitrogen, ND = not detectable, NO_3 = nitrate, NTU = nephelometric turbidity unit, OG = operational guideline, TCU = true color unit (platinum cobalt scale), TON = threshold odor number, U = unobjectionable, US EPA = United States Environmental Protection Agency.

[a] Aesthetic objective.
[b] < 1 NTU when disinfecting with chlorine.
[c] When fluoridation is practiced.

Continued on next page

Table—*Continued*

Selected Substance or Characteristic	Unit	World Health Organization			ECD (1980)		US EPA (1985)	CAN DWS (1994)	Recommended Project Standard for Bottled Water
		1993 Guideline Value	1971 Intl. Standard		Guideline Value	Maximum Admissible Concentration	Maximum Contaminant Level	Maximum Acceptable Concentration	
			Highest Desirable Level	Maximum Permissible Level					
Selenium	mg/L			0.01		0.01	0.05	0.01	0.01
Silver	mg/L					0.01			0.01
Sodium	mg/L	200			20	175		200[d]	< 200[d]
Sulfate	mg/L	400	200	400	25	250	250	500[a]	< 200
Zinc	mg/L		5	15	0.1		5.0	5.0[a]	5 .0
Anionic Detergents	mg/L		0.2	1.0		0.2			0.2
Mineral Oil	mg/L		0.01	0.3		0.01			0.01
Phenolic Compounds	mg/L		0.001	0.002		0.0005		0.002	0.001
Total Dissolved Solids	mg/L	1,000	500	1,500		1,500	500	500[a]	500
Conductivity	µS/cm				400				400
Total Hardness as Calcium Carbonate	mg/L	500	100	500		150 (min. value)		500[e]	< 250[e] [f]
Residual Chlorine	mg/L								
Trihalomethanes	mg/L						100	100	< 100
Polychlorinated Biphenyls	mg/L						0.5	(3)	0.5
Methane	L/m^3							(3)	3
Total Organic Carbon	mg/L							(5)	5
Pesticides	mg/L							[g]	[g]
Fecal Coliform Bacteria	per 100 mL	0						(0)	0
Total Bacteria	per 100 mL	0						[h]	< 3

µS = micro Siemens, cm = centimeter, m^3 = cubic meter, mL = mililiter.

[d] Notify medical officer when sodium concentration > 20 mg/L.

[e] Inferential standard: high enough to promote floc formation, but not so high as to cause gastrointestinal discomfort. Good (80–100 mg/L), poor (> 200 mg/L), and unacceptable (> 500 mg/L). From Ontario Ministry of Environment and Energy. 1994. *Ontario Drinking Water Objectives.* Ontario.

[f] Sufficient residual chlorine in finished water leaving the water treatment plant to obtain adequate chlorine residual in distribution system.

[g] The 1994 Ontario Drinking Water Objectives lists maximum acceptable concentration for 13 pesticides as follows:

- Aldrin + Deldrin 0.0007 mg/L
- Carbaryl 0.09 mg/L
- Chlordane 0.007 mg/L
- DDT + metabolites 0.03 mg/L
- Diazinon 0.02 mg/L
- Heptachlor + Heptachlor Epoxide 0.003 mg/L
- Lindane 0.004 mg/L
- Methoxychlor 0.9 mg/L
- Parathion 0.05 mg/L
- 2, 4-D 0.1 mg/L
- 2, 4, 5-T 0.28 mg/L

[h] The 1994 Ontario Drinking Water Objectives considers water unsafe when "total coliform bacteria are detected in consecutive samples from the same site or in multiple samples taken as a single submission from a distribution system."

Source: Operations Evaluation Mission.