SUPPLEMENTARY ECONOMIC ANALYSIS

A. Context of the Analysis

1. For technical and environmental reasons, creating a single sewage collection and treatment system integrating Koror and Airai is not feasible. The project, therefore, consists of two physically separate projects, though their costs and benefits are considered together.

2. In Koror, the existing system was first built in the 1970s. It consists of a central collection network feeding to a sewage treatment plant in Malakal. Though only about 60 percent of households are now connected to the system (about 1,890 of a total of approximately 3,149 households in Koror), the system is overloaded and performs poorly, as shown in Table SA1 below. Non-domestic connections (commercial establishments and the government, a total of 1,120 connections) account for about 40 percent of the total effluent treated.

Table SA1: Capacity vs Load, Koror Sanitation System

System Component	Capacity	Load	Shortfall (%)
SECT 1 - Central (Koror) Trunk Sewer (L/s)	46	37	None
SECT 2 - Central (Koror) Trunk Sewer (L/s)	42	102	243%
Sewage Pump Station SPS 1 (L/s)	(…)	172	(…)
SPS 1 Force Main (L/s)	110	172	156%
Malakal Trunk Sewer (L/s)	77	200	260%
Sewage Pump Station SPS 2 (L/s)	(…)	200	(…)
SPS 2 Force Main (L/s)	165	200	121%
Sewage Treatment Plant (kg BOD/day)	1,600	1,730	108%

Source: Asian Development Bank.

3. The system is poorly maintained, and leaks and overflows are a daily occurrence, threatening the livability of the urban area, inland and coastal areas, the coastal marine environment, agriculture (taro patches), and public health. As Palau depends on tourism for 50% of its national income (and most tourists spend the bulk of their time and money in Koror), the dilapidated system also poses a serious threat to future income prospects, as tourism is acutely sensitive to health issues.[1] The implicit threat of an outbreak of a waterborne disease epidemic will increase through time unless and until the system is rehabilitated, and if such an event were to occur, tourist arrivals can be expected to fall substantially and for an extended period. Under the proposed project, the number of domestic and non-domestic connections will be increased, leaking pipes will be replaced, the sewage treatment plant will be overhauled with expanded capacity, system maintenance will be strengthened, and overflows will be sharply reduced.

4. In Airai, some 325 households and a small number of businesses and public facilities (government offices and a school) make up the community of Kesebelau. The community was established on government land, with housing built and leased to the public. There is no sewage system in the area at present, and all residents are using septic tanks. Because of poor soil conditions for septic leaching, the septic tanks require frequent pumping (twice a week) in order to avoid overflows which, when emitted, largely flow on the surface, ponding in residential and agricultural areas. Surveys have shown that Kesebelau households do not carry out pumping with anything close to the required frequency, and surface flows have become continuous, threatening the habitability of the area. A simple sewage collection and package treatment

[1] International Monetary Fund (IMF). 2012. *Republic of Palau: 2012 Article IV Consultation, Staff Report, IMF Country Report* No. 12/54.

system is proposed, allowing the community to discontinue use of septic tanks, and thus eliminate the present requirement of frequent pumping.

5. In summary, the project will address looming threats to the public health and habitability of the urban areas of Palau, and will help to safeguard a land and coastal marine environment on which a continued vibrant tourism sector and a large part of national income depend.

B. Least-Cost Analysis

6. In Koror, three potential solutions have been identified to address the deficiencies of the present system: (i) the proposed project, which is a rehabilitated centralized collection system connected to an overhauled and expanded sewage treatment plant in Malakal; (ii) a new collection system routed around the coastal areas and connected to an overhauled and expanded sewage treatment plant in Malakal; and (iii) a decentralized collection and treatment system, resulting in eight new small collection and treatment plant systems distributed around Koror.

7. As all of the alternatives are subject to equivalent energy, maintenance, and personnel costs, the least-cost decision rests on a comparison of the respective economic capital costs, as summarized in Tables SA2–SA4 below.[2] The proposed project in Koror is least cost ($24.4 million compared to $33.0 million and $35.5 million for approaches 2 and 3, respectively) because it minimizes the need for procurement and installation of new facilities.

Table SA2: Approach 1 (Proposed Project): Centralized Collection System

Description	Amount ($)
Gravity Interceptor Sewer	3,065,875
Major Pump Station Upgrade	1,002,500
Minor Pump Station Rehabilitation	832,500
Major Force Main Upgrade	1,890,000
Sewage Treatment Plant	9,500,000
Overflow Management Facility	497,000
Public Toilet Facilities	97,500
Telemetry/Remote Monitoring	190,125
Consulting services (survey, design, tendering, supervision)	2,711,000
Consulting services (management support)	1,468,750
Physical Contingency	3,189,000
Total	**24,447,000**

Source: Asian Development Bank.

[2] Converted from financial costs by removing taxes.

Table SA3: Approach 2: Coastal Carrier System

Description	Amount ($)
Mangrove clearing and earth fill to accommodate new coastal gravity sewers etc	3,979,105
New coastal gravity sewers including: connecting existing system to new sewers	4,973,881
Decommission existing pump stations and rehabilitate sites	621,735
New pump stations to support coastal carrier system	2,437,202
New force mains to support coastal carrier system	559,562
SPS1 upgrade including overflow facility	298,433
SPS2 upgrade	74,608
SPS1 force main adjustment	346,928
SPS2 new force main	134,295
New SPSA8	248,694
New SPS8 force main	447,649
SPSA1 force main adjustment	130,564
New telemetry system	193,981
New Malakal STP	9,947,762
New and rehabilitated public toilets	149,216
Consulting services (survey, design, tendering, supervision)	3,558,825
Physical Contingency	4,908,723
Total	**33,011,163**

Source: Asian Development Bank.

Table SA4: Approach 3: Decentralized Collection & Treatment System

Description	Amount ($)
New satellite STPs	15,916,419
New STP Access	621,735
New pump station lift to north side to protect Necco Bay	696,343
New force main lift to north side to protect Necco Bay	417,806
Adjust existing gravity sewers to connect to new STPs	994,776
Mangrove clearing and earth fill to accommodate new STPs	795,821
New STP ocean outfalls	5,968,657
SPS1 upgrade including overflow facility	298,433
SPS2 upgrade	74,608
SPS1 force main adjustment	134,295
SPS2 new force main	134,295
New telemetry system	193,981
New and rehabilitated public toilets	149,216
Consulting services (survey, design, tendering, supervision)	3,827,476
Physical Contingency	5,279,277
Total	**35,503,138**

Source: Asian Development Bank.

8. In Airai, the least-cost analysis compares (i) continued use of septic tanks in Kesebelau, combined with pumping and cleaning operations of a frequency sufficient to eliminate the present surface flows of sewage with (ii) the proposed project – a centralized sewage collection and treatment system serving the same area. Alternative (i) is available at no initial investment cost but high operational cost, while alternative (ii) comes with a significant initial investment cost but comparatively low operational costs. The initial investment cost of the proposed project is summarized in Table SA5 below.

Table SA5: Airai Proposed Project, Initial Costs

Description	Amount ($)
Gravity Sewer Network	1,372,000
Package Sewage Treatment Plant	1,372,000
Minor Pump Station and Pressure Main	373,000
Physical Contingency (15%)	468,000
Total	**3,585,000**

Source: Asian Development Bank.

9. In addition, the estimated economic operation and maintenance (O&M) costs of the project include consumption of 75,000 kWh of electricity per annum, valued at about $38,000/year, and routine system maintenance of approximately $11,000/year, or a total of about $49,000 per year at startup. Over the project's operating period, the cost of electricity is assumed to increase in real terms per annum at the rate of 1.9%, consistent with rising diesel fuel prices. Under these assumptions, the net present value (NPV) of total costs of the project over its operating life, discounted at 12%, is approximately $4.0 million.

10. The approximately 325 households in Kesebelau that would be served by the project are expected to increase at an average rate of 3.3% per annum, reaching 645 households by 2036. There is also a small number of non-domestic (commercial and government facilities) in the area that would be served by the project (2 currently, increasing to 5 by 2036).[3] The frequency of pumping each septic tank, either of a household or a commercial establishment, required to prevent surface flows of effluent is estimated at twice per week, or 104 times per year.[4] The economic cost of pumping a septic tank of a household is conservatively estimated at $24 (accounting for fuel and maintenance), and that of a commercial or government establishment at $30.[5] These estimates are summarized in Table SA6 below.

Table SA6: Airai Alternative: Septic Tank Maintenance Costs (Frequent Pumping)

Item	Value
Number of household connections 2015	325
Housing growth rate	3.3%
Number of non-domestic connections 2015	2
Expected added non-domestic connections	3
Cost of pumping household septic tank ($/pumping)	24
Frequency of pumping (per household connection per year)	104
Cost of pumping non-domestic septic tank ($/pumping)	30
Frequency of pumping (per non-domestic connection per year)	104

Source: Asian Development Bank.

[3] There is a number of large hotels in the area also, but they have their own sewage treatment and disposal facilities and so are not expected to be connected to the project.

[4] Based on average expected volume input.

[5] The cost of purchasing tank trucks (6 working full-time are estimated to be needed to handle the expected volume of pumping) has not been included in the analysis, as it is likely that such trucks are available for hire from the private sector. Any need to purchase trucks would add substantially to the first-year costs of the septic tank pumping scenario.

11. Under these assumptions, the pumping required for septic tanks in Kesebelau will cost an estimated $791,000 in the first year, rising (because of increasing households) to about $1.6 million per year by the end of the period. The NPV of total costs of pumping operations over the life of the project (to 2036), discounted at 12%, is approximately $7.7 million. It is therefore concluded that the proposed project is the least-cost alternative in Airai in terms of life cycle costs.

C. Methodology

12. A 'with project' scenario is compared directly to a 'without project' scenario in order to make explicit the benefits of the project and its incremental costs over the project lifetime. Costs and benefits under both scenarios are discounted at the standard economic opportunity cost of capital (EOCC) of 12%.

13. The local currency in Palau is the United States dollar. There are no levies or duties on imported materials. Local labor is taxed at 6% on all income up to $8,000 per year, and at 12% on income exceeding $8,000/year. Taxes are excluded from the economic costs.

14. As Palauans have free rights to migrate and work and claim social benefits in the United States, there is virtually no unemployment in Palau and local wage rates are an accurate measure of the opportunity cost of labor. Under these circumstances, it is estimated that the shadow wage rate and exchange rate factors necessary to equilibrate the border and domestic price levels of traded and non-traded goods in Palau are not materially different from 1.0.

D. Project Economic Costs

15. Project economic costs include the initial costs associated with (i) civil and mechanical works and equipment associated with the development or rehabilitation of sewage collection and treatment facilities; (ii) surveys and other technical investigations contributing to detailed design; (iii) consulting services for carrying out design work, tendering, implementation supervision, and management support activities; and (iv) a physical contingency allowance. Economic costs associated with the operational phase of the with-project scenario include (i) incremental routine repairs and maintenance; (ii) asset replacements scheduled according to the frequency with which they are expected to wear out; and (iii) incremental energy costs. Operational phase costs include personnel costs. The residual value of sewerage assets at the end of their economic life is zero.

E. Project Economic Benefits

16. In both subproject areas (Koror and Airai), the objective of the project is to reduce the significant public health and associated environmental risks of poor sanitation by substantially reducing sewage overflows (in Airai, these are caused by improper maintenance of septic tanks), improving responsiveness of operators to emergencies, and ensuring that effluent ultimately discharged to the environment is properly treated. As mentioned above, in the case of Koror (and Palau generally), a key consideration in protecting the environment from pollution from wastewater and foul air is to protect incomes—the economy depends crucially on tourism. Deterioration of Palau's pristine marine and coastal environments—potentially leading to an outbreak of water borne disease such as cholera or typhoid—would cause grievous damage to the tourism industry in Palau and destruction of livelihoods requiring multiple years to recover, in addition to having a potentially devastating impact on the local population.

17. A common approach to quantifying the benefits of improved sanitation, as with an incremental water supply, is to estimate the beneficiaries' willingness to pay for the improved service. This provides a direct measure of the beneficiaries' perception of the economic benefit of the improvement to them. In Palau, however, the cost and effectiveness of sanitation (and of government services in general) is a highly charged political issue, and it is unlikely that a concerted effort to obtain willingness to pay data by survey in the present climate will reap meaningful results. The approach to economic analysis adopted for present purposes measures (i) in Koror, the direct economic impact of operation and maintenance (O&M) savings, avoided costs due to sewage overflows in terms of health care, environmental clean up by the government, households, and the commercial sector, and detrimental impact on tourism; and (ii) in Airai, the avoided costs of properly operating and maintaining septic tank systems in the residential area of Kesebelau. In both subprojects, there is a small but significant benefit of local employment associated with project implementation.

18. The economic benefits including in the analysis of each subproject and the method of quantification of each are summarized below.

F. Koror Subproject

19. The economic analysis of the Koror subproject rests on five quantified benefits: (i) reductions in asset replacement costs due to improved asset management resulting from the project; (ii) avoided health costs and production losses that arise due to gastrointestinal infections resulting from exposure to sewage overflows; (iii) avoided costs to government, households, and the commercial sector to clean-up land, coastal, agricultural, and inhabited areas after overflows occur; (iv) increased local employment during implementation; and (v) avoided loss of national income that occurs because of overflows that may cause an outbreak of a life-threatening contagious disease such as cholera or typhoid, in turn leading to a sharp and sustained downturn in tourist arrivals in Palau.

20. **Improvements in asset management.** The entity responsible for operating and maintaining the Koror sewage system lacks appropriate control mechanisms for pumps and other equipment, which therefore wear out and need to be replaced well before their design life expires. Under current conditions assumed to continue without the project, sewage pumps in pump stations typically need to be replaced every 5 years compared to a design life of 15 years, and electrical control boards need to be replaced every 10 years compared to a design life of 20 years. By introducing inexpensive but effective control mechanisms and by applying a coherent asset management plan under the project, these assets will last and remain operable for their full design lives.

21. There are 45 minor pump stations in Koror, each with 2 pumps valued at $15,000 each, and 2 major pump stations, each with 4 pumps valued at $75,000 each. Replacing all pumps incurs a cost of $1.95 million. There is one electrical control panel in each pump station. Control panels are valued at $30,000 and $150,000 in minor and major pump stations, respectively. Replacing all control panels incurs a cost of $1.65 million.

22. With the project, pump, and control panel replacements occur relatively far in the future (15 years for pumps and 20 years for control panels, after the start of operations). Expenditures for replacing these assets with the project have a net present value (discounted at 12%) of $375,000. In comparison, without the project, asset replacements continue from the present every 5 years for pumps and every 10 years for control panels, and have a net present value of

$3.0 million. The difference ($2.62 million) between the net present asset replacement costs of the with-project and without-project scenarios is included as a benefit of the project.

23. **Health benefits (avoided costs of treatment and lost production).** The Ministry of Health has released monthly data on the incidence of gastroenteritis (GI, inflammation of the stomach and intestines due to ingestion of harmful bacteria) that shows a strong correlation between sewage overflows and recorded cases of the disease. In the period from 1 April 2011 to 31 March 2012, the ministry recorded 862 cases in Koror, of which 429 or 50 percent occurred in the three months from November 2011 through January 2012.[6] That period of 3 months was also when the Aimeliik power station was out of service due to a fire, and the Koror sewage pump stations could not function. Sewage overflows during that period were continuous, and account for the very high incidence of GI cases during that time. During normal times, sewage flows are also common. A significant overflow is estimated to occur on average twice per week in Koror and reported GI incidence (less than actual incidence, since many if not most cases, go unreported) averages 40–50 cases per month. On this basis, it is assumed that the average number of cases in Koror of GI and other serious waterborne diseases requiring medical care is 10 per significant sewage overflow. The economic cost of medical care per case, accounting for the opportunity cost of doctors' and nurses' time and hospital occupancy ($40 per case) and medicines required for treatment ($10), is estimated at $50. In addition, it is assumed that a diagnosed case of GI or other serious water borne disease requires the patient to lose 5 working days. Production lost during such 'sick days' is valued at $3/hour or $24/day or $120/case. In combination with treatment costs, the economic cost of GI is thus valued at $170 per case, or $1,700 per overflow.

24. As mentioned, the current frequency of serious overflows in Koror is estimated at two per week or 104 per year. It is further assumed that, without the project, the sewer system will continue to deteriorate, pumps will fail more frequently, blockages will become more frequent, and pipes will become more leaky, all leading to a gradually increasing frequency of overflows. Due to these causes, the frequency of overflows is assumed to increase at the rate of 5% per annum.

25. Under these conditions, avoided costs (with the project) for medical treatment and lost production due to infection from overflows is calculated at about $177,000 per annum in the first year of operations, rising gradually to $469,000 per annum by the end of the project period, resulting in a net present value of $1.5 million as a project benefit.

26. **Avoided costs due to clean-up of overflows.** The service provider responsible for operating and maintaining the Koror sewage system is required to make frequent emergency responses for clean-up of overflows, at considerable cost per incidence. In cases where overflows are not actually cleaned up by the service provider, costs are still borne by those directly affected (e.g., households facing ponding sewage in close proximity their living area will suffer direct clean-up costs or a loss of living standard and use of property and assets; commercial establishments such as tourist resorts or restaurants will undertake strenuous activity to cleanup effluent in their vicinity in order to avoid losing customer patronage, etc.). The actual cost of clean-ups of historical overflows has not been recorded. To estimate the economic cost conservatively, it is assumed that cleaning up an overflow and appropriately disposing of the effluent costs a multiple (100%) of the existing cost of collecting and treating effluent in the sewage system in Koror. Further, given the current estimated frequency of

[6] ADB. 2009. *Technical Assistance to the Republic of Palau for Sanitation Sector Development* preliminary environmental estimate. Manila.

significant overflows (104 per year), it is estimated that approximately 20% of the full volume of effluent in Koror is accounted for by overflows and that the remaining 80% is treated successfully within the system. Under these assumptions, the estimated cost of a clean-up per overflow (shared as an economic cost by all households, commercial establishments, or government entities affected) is approximately $14,900. As discussed above, without the project it is assumed that as the system continues to deteriorate, the frequency of overflows increases through the planning period at the rate of 5% per annum.

27. With the project, overflows will be sharply reduced, but not 100% eliminated. It is estimated that in the first year of operations, an overflow will occur once in two months (i.e., 6 per year), falling to 2 per year by the end of the first ten years of operations. The total volume of effluent involved in overflows will fall to 2% of the total volume during the first 10 years, falling further to 1% thereafter. The with-project overflows will also be less severe than those without the project, and will incur an economic cost of about $3,000/overflow. The without-project overflow clean-up costs have an estimated NPV of $13.1 million, offset by the NPV of with-project clean-up costs of $0.1 million; the difference ($13.0 million) is included as a project net benefit.

28. **Local employment benefit.** During the 3-year construction period of the Koror subproject, local labour will be employed, generating local earnings estimated at about $2.3 million.

29. **Prevention of damage to livelihoods derived from tourism.** Koror and the adjacent areas contain beautiful tropical seascapes and diving opportunities that have helped to make Palau a major international attraction and tourism to contribute about half of the country's gross domestic product (GDP), as mentioned above. However, the tourism sector in Palau as elsewhere is highly vulnerable to health threats, similar in this respect to terrorism threats. Frequent overflows cause foul smells in places where tourists congregate and often lead to closure of near-shore waters for tourist use; a critical threat in the dense urban environment of Koror is that of a major outbreak of serious water-borne disease such as cholera or typhoid that could arise from human exposure to raw sewage. Past experience with epidemics (e.g., severe acute respiratory syndrome and bird flu) in other parts of the world suggest that tourism in the affected areas is severely dampened and takes a number of years to recover. In a small economy such as Palau's, such an impact would be (and, as was seen to a degree in the wake of the 9/11 terrorism when tourist traffic worldwide was diminished, was) devastating to local livelihoods.

30. The sewage system in Koror is already overloaded, leaky, and subject to frequent overflows, presenting a considerable risk to the public health. It is a widely held view among health and tourism sector stakeholders that there is already a significant and rising risk of an outbreak of a seriously contagious water-borne disease, such as cholera or typhoid. [7] Such an outbreak would drive away tourist visitors to Palau and jeopardize the longer-term prospects of the tourism sector. In this sense, the proposed project can be viewed as an insurance policy, addressing the risks faced by an economic sector vital to Palau's national income.

31. According to the International Monetary Fund (IMF) *2012 Article IV Consultation* in Palau, a one percentage point change in the growth rate of tourist arrivals is estimated to

[7] Social surveys conducted in Koror under this PPTA indicate serious concerns in this regard by public officials (Palau Visitors Authority) and resort/hotel owners. Resort/hotel owners are also increasingly concerned by the health risk to guests of sewage overflows.

change real GDP growth in Palau by 0.2 percentage points on average, based on an analysis of the historical relationship between GDP and tourist arrivals. A model has been developed for the economic analysis to measure this effect with respect to impacts on tourist arrivals from hypothesized probabilities (measures of risk) of a cholera/typhoid outbreak occurring as a result of human exposure to contamination from the dilapidated sewage system. The model's parameters and assumptions are summarized below.

32. Based on the above-referenced IMF report, the projected medium- to long-term growth rate in Palau's real GDP is 2% per annum. In current dollars, the 2011 GDP was approximately $221 million and at the indicated growth rate will be about $230 million in constant dollars in 2013. To begin the analysis, it is assumed that, without the project, the probability (i.e., level of risk) of an outbreak of cholera/typhoid is one incident every twenty years, i.e., 5% per annum, and that, due to continued deterioration of the sewage system, the probability itself increases by 5% in each year through the planning period.[8] It is further assumed (conservatively) that if and when such an incident occurs, the growth rate of tourist arrivals in Palau will decline by 30%, and the decline will be sustained for 2 years. Applying the IMF's ratio of change in tourist arrivals growth to change in real GDP growth of 0.2, these assumptions imply an immediate change in the real GDP growth rate, if and when an incident occurs, from 2% to -4% [= (1+2%+(-30%*0.2))-1].

33. To determine the expected value of the risk to tourism posed in each year by the dilapidated sewage system, the above change in real growth, which applies only if the incident occurs, is multiplied by the applicable probability of an incident occurring in a particular year (e.g., 5% in 2013) and a factor which incorporates the expected 2-year impact of the tourism decline. When an incident occurs, the second year of decline in national income is discounted by 12% to place the impact in present value terms at the start of the year in which the impact occurs.

34. Under these assumptions, the value of the risk to national income from tourism posed by the dilapidated sewage system without the project is estimated at $1.4 million (0.5% of Palau GDP) in 2013, rising to $2.4 million (0.9%) in real terms[9] by 2025, and $5.5 million (1.5%) by 2036.

G. Airai Subproject

35. The economic benefit of the project in Airai is the avoided costs, with the project, of preventing surface flows of sewage without the project, which entails frequent pumping of sludge from all septic tanks by tank truck and cartage and proper disposal of it at the sewage treatment plant (without the project, the relevant plant is in Malakal). The essential economic benefit of the project is thus the higher efficiency and lower life-cycle cost of a centralized collection and treatment system used in place of continuing with a septic tank-based system. (Improved sewage treatment per se is not part of the postulated economic benefit, since it is assumed that pumping sewage and carting it to a treatment plant will result in the same quality of treatment as treating it in a new plant in Airai; the difference that matters is in the costs of collection and treatment.)

[8] For example, if the probability which starts at 5% in 2013 is increasing at 5%/year without the project, the probability will double (i.e., reach 10%) after about 14 years (by around 2027).

[9] Expressed in 2011 dollars.

36. The costs associated with frequent pumping of septic tanks in Airai are discussed above in the least-cost analysis section of this report. With the project, these costs are avoided and constitute the project benefits.

H. Economic Internal Rate of Return (EIRR) and Economic Net Present Value (ENPV)

37. Under the parameters and assumptions discussed above, the EIRR of the two subprojects is 18.4%, with an NPV (discounted at 12%) of $14.3 million. The EIRR is considered to be acceptable as it exceeds the economic opportunity cost of capital adopted for this analysis of 12 percent. The EIRR/ENPV calculation table is shown overleaf in Table SA7.

Table SA7: Calculation of the EIRR and ENPV (Koror and Airai Sanitation Projects)

All values USD '000

	Costs					Benefits							
Year	Capital Costs	Incremental O&M Costs	Overflow Clean up Costs	Asset Replacement Costs	Total Costs	Avoided Asset Replacement Costs	Incremental Local Labour Earnings	Avoided Septic Tank Pumping Costs	Avoided Health Care Costs	Avoided Overflow Clean up Costs	Avoided Detrimental Tourism Impact	Total Benefits	Net Benefits
2013	9,636	-	-	-	9,636	-	1,002	-	-	-	-	1,002	- 8,634
2014	12,155	44	-	-	12,199	-	1,143	791	-	-	-	1,935	- 10,264
2015	6,077	45	-	-	6,122	-	572	817	-	-	-	1,389	- 4,733
2016	-	178	18	-	195	-	-	844	177	1,550	1,404	3,975	3,780
2017	-	187	18	-	205	-	-	872	186	1,628	1,504	4,189	3,984
2018	-	198	18	-	215	1,950	-	901	195	1,709	1,611	6,365	6,150
2019	-	208	18	-	226	-	-	931	205	1,794	1,725	4,654	4,428
2020	-	219	18	-	237	-	-	961	215	1,884	1,847	4,907	4,671
2021	-	230	18	-	248	-	-	993	226	1,978	1,978	5,175	4,927
2022	-	242	18	-	260	-	-	1,026	237	2,077	2,119	5,459	5,199
2023	-	255	18	-	272	3,600	-	1,059	249	2,181	2,269	9,359	9,086
2024	-	267	18	-	285	-	-	1,094	261	2,290	2,431	6,076	5,791
2025	-	281	18	-	298	-	-	1,140	274	2,405	2,603	6,422	6,123
2026	-	294	6	-	300	-	-	1,177	288	2,525	2,788	6,778	6,478
2027	-	309	6	-	315	-	-	1,216	302	2,651	2,986	7,155	6,840
2028	-	323	6	-	329	1,950	-	1,256	318	2,784	3,198	9,504	9,175
2029	-	339	6	30	375	-	-	1,297	333	2,923	3,425	7,978	7,603
2030	-	355	6	-	361	-	-	1,339	350	3,069	3,668	8,426	8,065
2031	-	371	6	1,950	2,327	-	-	1,383	368	3,222	3,928	8,901	6,574
2032	-	389	6	-	394	-	-	1,428	386	3,383	4,207	9,405	9,011
2033	-	406	6	-	412	3,600	-	1,475	405	3,553	4,506	13,539	13,127
2034	-	425	6	30	461	-	-	1,524	425	3,730	4,826	10,506	10,045
2035	-	444	6	-	450	-	-	1,574	447	3,917	5,169	11,106	10,656
2036	-	464	6	1,650	2,120	-	-	1,626	469	4,113	5,536	11,743	9,623
NPVs	25,334	1,591	90	383	27,397	2,995	2,478	7,694	1,494	13,100	13,915	41,677	14,280
EIRR													18.4%

Source: Asian Development Bank.

38. The project provides considerable benefits to Palau and the people of Koror and Airai, by reducing the threat of damage to public health and to livelihoods, and by reducing the costs of maintaining an environment free of pollution from effluent. The project represents a considerable improvement to the allocation of public and private resources in comparison to continuing to cope with the effects of a weak and deteriorating sewage system.

I. Sensitivity Analysis

39. Sensitivity analysis was carried out for adverse variations (by 20%) in the following parameters: (i) increase in capital and asset replacement cost; (ii) increase in incremental O&M cost; (iii) increase in rate of real increase in electricity price; (iv) decrease in incremental local employment; (v) decrease in avoided asset replacement, health care, septic tank pumping, and overflow clean-up costs; and (vi) decreases in avoided tourism impact. The sensitivity analysis results are summarised in Table SA8.

Table SA8: Sensitivity Analysis

Test Case	Test Variation (+/- %)	ENPV	EIRR	Sensitivity Indicator (SI)	Basecase Parameter	Switching Value (SV)	Switching Value (+/-%)
Base (reference case)		14,280	18.4%				
Increases in Costs							
Capital and Asset Replacement Costs	20%	9,137	15.6%	1.80	25,717	39,997	55.5%
Incremental O&M Costs	20%	13,944	18.3%	0.12	1,680	15,961	849.8%
Electricity Price Escalation Rate	20%	14,223	18.4%	0.02	1.9%	8.3%	336.3%
Decreases in Benefits							
Avoided Costs	-20%	9,223	16.3%	1.77	25,284	11,004	-56.5%
Incremental Local Labour Earnings	-20%	13,784	18.1%	0.17	2,478	-	-100%
Detrimental Tourism Impact	-20%	11,497	17.3%	0.97	13,915	-	-100%
Costs Increased and Benefits Decreased	20%	397	12.2%				

A "Switching Value (+/-%)" of -100% indicates that reducing the parameter to zero does not reduce the economic internal rate of return below the 12% threshold.
Source: Asian Development Bank.

40. The project EIRR remains above 12% when each of the adverse variations is applied, and for all of them applied simultaneously. The most sensitive parameter is found to be capital and asset replacement costs, with a sensitivity indicator (SI) of 1.80, indicating that, say, a 10% variation in such costs will result in a 18% change in the NPV of the project. Calculations of the switching value (the value of a parameter at which the project EIRR reaches the threshold of economic viability, 12%) show that capital and asset replacement costs can rise by approximately 56% before the EIRR falls below 12%, all other parameters equal. The next most sensitive parameter is the combined avoided costs included as benefits apart from tourism (avoided health, cleanup, asset replacement, and septic pumping costs), with SI=1.77, but such benefits could fall approximately 57% before EIRR falls below 12%. The avoided tourism impact parameter has an SI of about 1.0, but if this benefit were to fall to zero, the project EIRR would fall close to, but remain above, 12%. Variations in the other parameters are not significantly sensitive in terms of the economic outcome of the project.