THE INFLUENCE OF MODERN WATER SUPPLY AND WASTEWATER TREATMENT SYSTEMS ON WATER QUALITY IN MICRONESIA

By

Peter A. Cowan

UNIVERSITY OF GUAM

Water and Energy Research Institute of the Western Pacific

Technical Report No. 36

August, 1982

Project Completion Report

for

THE INFLUENCE OF MODERN WATER SUPPLY AND WASTEWATER TREATMENT SYSTEMS ON WATER QUALITY IN MICRONESIA

Project No. A-020-Guam, Grant Agreement Nos. 14-34-0001-0112, 1112

Principal Investigator: Peter A. Cowan

Project Period: April 1, 1980 to June 30, 1982

The work on which this report is based was supported in part by funds provided by the United States Department of the Interior as authorized under the Water Research and Development Act of 1978.

ABSTRACT

The near shore marine environment surrounding the district centers of Koror (Palau) and Kolonia (Ponape) was evaluated with respect to selected physical and bacteriological parameters. The baseline data measured in this study will serve to quantify ambient (natural background level) conditions for the expressed purpose of: A) acting as a basis of comparison against which future data may be judged; B) identifying areas of poor water quality, areas which could improve in quality given complete implementation of a fully operational wastewater collection/treatment/disposal system. In Koror, those areas immediately east and west of T-Dock and the small bay adjoining the Community Club should experience such improvements. In Kolonia, all near shore marine areas should be positively impacted. The waters surrounding Ponape, a high island, will continue to suffer from high turbidities during sustained rainfall events; areas of concern are those impacted by freshwater (stream) inputs.

Since the highest priority water quality monitoring program in the micronesian trust territories is the continuous evaluation of the public water system (PWS), a concurrent study was performed on the distribution systems in these two district centers (limited data from the Colonia [Yap] system were included in the PWS evaluation). Numerous drinking water standard violations were measured in each system: Colonia - excessive turbidities and coliform densities accompanied by negligible free residual chlorine (FRC) levels at distribution points; Koror - turbidity and coliform violations; Kolonia - coliform violations. The systems in Colonia and Koror are operated on an intermittent basis and, as such, patrons should boil PWS water prior to culinary uses. The service in Kolonia is continuous; however, until improved chlorination practices at the water treatment plant (WTP) are effected, the boiling precaution should be mandatory until district center PWS coliform densities are consistently negligible.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

INTRODUCTION

The Trust Territory of the Pacific Islands (TTPI) consists of more than 2000 islands (landed mass: 1362 square kilometers) and encompasses roughly 7.8×10^6 square kilometers in the western Pacific Ocean (Figure 1). Approximately forty per cent of the population of the TTPI is concentrated in seven district centers where the various governments and concomitant jobs and social services are located. A major destructive force upon the integrity of the marine environments surrounding these areas of high population density is and has been the failure to collect, treat and dispose of human wastes. To combat this deficiency, capital improvement projects (CIP) are instigated in the various district centers in order to establish and integrate water collection/treatment/distribution systems with wastewater collection/treatment/disposal systems.

The quality of the marine waters surrounding the district centers is suspected to be very poor. Diseases, partially attributed to this substandard water quality, are common. Implimentation of water and wastewater systems focuses upon the overall improvement in water quality such that the incidence of waterborne diseases will decrease and eventually become non-existent. Improvements in marine water quality will substantiate recommendations for establishment of similar facilities in other areas of Micronesia. Identification of those areas where improvements in water quality have not been quantified will serve as a basis for recommendations to public works and sanitation officials to take action to improve environmental conditions.

Due to the existence of numerous constraints which inhibit the completion of environmental research efforts in Micronesia (currently and in the foreseeable future), the only possible (realistic) monitoring strategy is one which is established on the local level in each district center Environmental Health Laboratory. Since local technicians and specialists will be directly involved in every aspect of the execution of such a strategy, it is of primary importance that any environmental water quality sampling and analysis program should always be performed in liason with local sanitation officials. Development of expertise in water quality monitoring and reporting skills is the responsibility of the Trust Territory Environmental Protection Board (TTEPB); therefore, any training efforts should be coordinated with the TTEPB.

In any analysis of environmental impact, it is essential that the existing conditions of the impacted system be known. The need to establish the background levels of various water quality parameters in the marine environments surrounding the district centers in Micronesia exists due to an almost total lack of data. Baseline data will serve as a basis of comparison against which subsequent data (gathered by local technicians) may be evaluated to ascertain the environmental impacts of the establishment of a functioning community wastewater collection/treatment/disposal system.

OBJECTIVES

The marine environment immediately surrounding the district centers of Palau (Koror) and Ponape (Kolonia) were each evaluated for a period of approximately one month. Specific water quality parameters quantified included: bacteriological (total and fecal coliform); physical (water temperature, salinity, pH, turbidity and dissolved oxygen). Since the principal water quality monitoring priority in the TTPI is the continued evaluation of the district center Public Water System (PWS), a concurrent monitoring program was maintained to study the bacteriological (total coliform) and physical (water temperature, specific conductance, pH, and turbidity) integrity of the drinking water distribution system.

The Water and Energy Research Institute of the Western Pacific (WERI) field team was conscientious in their efforts to involve local personnel in every phase data gathering and processing such that the secondary objective of training was accomplished.

Summary of specific project objectives in Palau and Ponape:

1. Establishment of marine baseline water quality in those areas immediately adjacent to and adversely impacted by the district center populace.

2. Identify those areas where water quality violations occur and target them for analysis of potential positive impacts (improvement in quality) as a result of the establishment of a functional wastewater collection/treatment/disposal system.

3. Evaluate the safety of the fresh drinking water distribution system during the study period and advise local sanitation officials of any violations which might lead to adverse public health.

4. Work directly with the local Safe Drinking Water Specialist (distribution system) and the Environmental Specialist (marine system) and provide on site training in water quality sampling (field) and analytical (laboratory) techniques and procedures.

5. Collect, collate and evaluate the district center marine and fresh-water distribution system water quality data from the Environmental Health Laboratories in Koror and Kolonia.

LITERATURE REVIEW

A comprehensive review of the literature for the islands and atolls of the seven district centers of the TTPI (Constitutional Government of the Marshall Islands: DUD Area of Majuro Atoll and Ebeye of Kwajalein Atoll; Government of the Republic of Belau: Koror; Federated States of Micronesia: Ponape-Kolonia, Kosrae-Lele, Truk-Moen, Yap-Colonia) appears in Cowan and Clayshulte (1980). This previous baseline study quantified marine water quality on an island-wide basis; therefore, only a portion of that data (data pertaining to the marine environments surrounding the district centers of Koror and Kolonia) will be summarized.

Marine water surrounding the district center of Koror was concluded to be of very high quality with no violations of TTPI marine water quality standards existing for the study period: 19-21 December 1979 (Cowan and Clayshulte, 1980). The data for six sites (Class AA: Iwayama Bay southeast of the weather station; Class A: Iwayama Bay south of Continental Hotel and waters west of the Renrak Bridge area; Class B: T-Dock southeast of PMCA, Komebail Lagoon waters north of Sechemus [between T-Dock and MOC], and Malakal Harbor east of Van Camp) are summarized in Table 1. The descriptions of the TTPI marine water classifications are listed in Table 2 and the TTPI proposed marine water quality standards (Cowan and Clayshulte, 1980) are represented in Table 3.

A recent task force report on point and nonpoint sources of pollution in the Territories (TTPI, 1979) highlights specific areas on Koror where existing and potential negative impacts are prevalent. These areas should experience improvements in water quality upon implimentation of functional wastewater collection/treatment/disposal systems. The benjos (over the water outdoor privies) and pig pens in the vicinity of T-Dock as well as sewage discharges via septic tank leach fields at the Micronesian Occupational Center (MOC) and Palau High School represent the primary threats to the integrity of the marine environments in their respective areas. In the M-Dock area of Koror, the storage and handling of light fuel, the presence of an open refuse dump, dredging and earthmoving activities represent potential pollutional sources. Properly managed, however, these sources can be controlled. The remaining areas of concern identified by the task force exist on Malakal Island: the sewage treatment plant (STP) outfall into Malakal Harbor; bilge and toilet discharges from ships at the Port of Palau; Van Camp processing plant (NPDES [National Pollutant Discharge Elimination System] Permit); fisherman's co-op discharges; coconut oil processing plant discharges; oil discharges from the operation of the power plant. The marine environments in these areas should be continuously monitored in order to evaluate and identify any negative water quality impacts.

The marine water quality data gathered by the local Environmental Health Laboratory staff from 1978 to the present time are presented in Table 4. Prior to July 1980, the only documented region of contaminated marine water was in the T-Dock area (sites 1, 4 and 5: Table 4). As a result of the current marine evaluation study herein reported, the small bay adjoining the old Community Club was discovered to have, at times, excessively high Fecal Coliform densities. The extent of the danger to human health of the residents of this area is quantified in this study and is confirmed in the October/November 1980 samples (site 8: Table 4).

The poor quality of the marine waters surrounding Kolonia (Ponape: 8-10 January 1980) was exemplified by numerous water quality standards violations (Cowan and Clayshulte, 1980). The data for sites 6 (Mwalok Channel near the STP outfall) and 7 (marine waters east of Kolonia), sites which are adjacent to Kolonia and therefore relevant to the present study, are listed in Table 5. These areas were negatively impacted by fresh water inputs from rivers in their respective areas. The excessive increases in turbidities and coliform densities and the lower salinities measured at these sites were but several manifestations of the adverse impacts of the heavy rains which occurred on Ponape (Jaunary 8 and 9, 1980) during the study period. The high Fecal and Total Coliform levels indicated the presence of a public health hazard in the marine waters east of Kolonia (site 7). All Fecal Coliform: Total Coliform ratios exceeded 0.20; this is indicative of recent contamination of the water resource by raw wastewater (Orsanco, 1971). The bacteriological and physical water quality data gathered from the other sites (Cowan and Clayshulte, 1980) are also summarized for purposes of comparison.

The task force report on pollutional sources (TTPI, 1979) lists the Tawenmokol and Mwakol Channels areas next to Kolonia, as regions of poor water quality. Human and animal wastes are targeted as the prime causes of surface water pollution. Benjos and pig-pens are polluting streams, rivers and near shore marine environments. Sewage discharges from hotels (Ekilis Hotel specified) prompted inclusion of marine areas near the Ekilis, Kohler's, Nanmadol, Pohnpei and South Park Hotels as sites in the current investigation.

Marine bacteriological water quality data collected by the Kolonia Environmental Health Laboratory staff are presented in Table 6. Numerous (18) Fecal Coliform standard violations (≥400/100 mℓ) are quantified, with TNTC (Too Numerous To Count) values representing potential violations (23 of 69 samples). The FC:TC ratios exceeded 0.20 in 58 of the 69 samples listed, thereby indicating human or animal contamination of waters tested.

Future water resources research projects in Micronesia should always be coordinated through the TTEPB (Saipan) and any interested local agencies on the island(s) under investigation. If the research team includes water quality technicians and/or specialists, time should be alloted to assist local environmentalists in their monitoring programs (freshwater distribution system and marine waters). The TTEPB directs monitoring programs in the TTPI; uniform field/laboratory equipment, supplies and sampling/analytical techniques are absolutely necessary for rational operation of such programs. Nothing could be more damaging to future monitoring efforts than to have "outsiders" come into any of the district centers laboratories with non-authorized and improperly referenced and documented field/laboratory procedures (F. Yamada, Environmental Specialist, Koror, Palau; personal communication, 1980). Standard laboratory equipment/supplies and analytical techniques are listed in a recent report to the TTEPB (Cowan, 1980).

In order to augment and promote continued monitoring of the Public Water Systems (PWS) in the Territories, sampling programs were expanded for the study periods in Colonia (Yap), Koror and Kolonia. The PWS data gathered by local officials prior to and following the respective study periods are summarized in Tables 7 and 8 (Koror) and 9 (Kolonia). It is noted that no data were available for Colonia.

In the district center of Koror, water distribution is severely limited due to a high demand which far exceeds the ability of Public Works to supply water to Koror. It is doubtful that consumption accounts for this demand; instead, it is water wasteage through leaky fixtures and "leaving taps on when not in use" as well as water losses through suspected yet not confirmed leaks in the distribution which limit Koror to water hours: 0600-0800, 1800-2000. As a direct result of this continuous interruption of service, the quality of the drinking water is consistently below standards necessary for maintenance of public health. Turbidity levels exceed the safe drinking water standard (≤1.0 NTU) in three of the four months recorded between October 1978 and November 1980 (Table 7). Twenty four of the bacteriological standard violations (26 in all) were accompanied by zero Free Residual Chlorine (FRC: Table 8) levels at the distribution system sampling points. Violations of Total Coliform presence (>1 TC/100 mℓ: monthly arithmetic mean; >4 TC/100 mℓ in more than one sample) were quantified in: 1978 - October; 1979 - January, February, August; 1980 - January, December; 1981 - January, May. It is the recommendation of sanitation officials that residents boil any water used for direct consumption and food preparation (L. Abraham, Safe Drinking Water Specialist, Koror; personal communication, 1980).

The only PWS in the TTPI to consistently supply drinking water to its district center population is located in Kolonia. Due to lack of equipment, only relatively few turbidity readings were taken by local sanitarians (Table 9) and these data are suspect (equipment malfunction): the nine water treatment plant (WTP) influent (surface water source) samples analyzed had turbidity levels ≤0.2 NTU. Twelve of the 16 measured bacteriological standard violations were due to lack of FRC at their respective points of distribution; it is noted that no FRC data were available for three of the remaining four violations. The presence of turbidity in the drinking water is a probable cause of these depressed FRC values since Chlorine was added (except for a period around January, 1980) at the WTP. The presence of Fecal Coliform (Table 9), a sign of serious potential health hazard, was quantified in: 1977 - November; 1978 - December, 1979 - November and December; 1980 - January, February and May. This contamination resulted from surface pollution at the source (and entered the distribution system because of inadequate filtration and/or chlorine contact times necessary to kill these indicator organisms) or possibly from infiltration into the distribution system during periods when service was interrupted. The violation of Total Coliform standards occurred in the aforementioned months as well as in: 1980 - September. The seriousness of the presence of Fecal Coliform can not be overstressed; local officials advised residents to boil culinary water during these months (W. Likaksa, Safe Drinking Water Specialist, Ponape; personal communication, 1980).

Contamination of community (Table 10) and private (Table 11) water systems from human/animal wastes is prevalent on Ponape. Massive education programs must be instigated such that protection of these water sources for human consumption in those areas outside Kolonia becomes a reality. No more shocking example of this excessive risk to public health exists than has been quantified at the Village Hotel (Table 10). Protection of water resources, specifically those resources utilized for human consumption, should have the top priority of the State of Ponape.

MATERIALS AND METHODS

Marine water quality samples (surface grab) were taken from a boat in each district center studied (Koror and Kolonia). Dissolved oxygen samples were fixed immediately by adding the first two reagents, vigorously shaking and storing the sample bottle out of direct sunlight. Water temperature, salinity and free residual chlorine (FRC) levels were assessed on site. After the first several sample periods, FRC measurements were only made at the sewage treatment plant (STP) outfall sites. Bacteriological samples (Fecal Coliform, FC; Total Coliform, TC) were taken in sterile Whirl-Pak bags; sampling procedures included avoidance of hand contamination of the sampled water. Samples for turbidity and pH determinations (a single 250 milliliter [mℓ] bottle per site) as well as the bacteriological sample bags were stored in an ice chest for transport to and analysis in the laboratory (local Environmental Health Laboratory).

Freshwater distribution system water quality samples were obtained from designated water taps after the water had been allowed to flow for two minutes (at maximum flow) to flush the lines. The samples were taken with the taps nearly closed to avoid sample aeration. Water temperature, specific conductance and FRC levels were quantified on site. Bacteriological samples (Total Coliform, TC) were placed in special sterile bags (containing 10 milligrams [mg] of sodium thiosulfate for FRC neutralization). On sample dates following positive TC assays (Kolonia only), a second sterile bag was filled for FC analysis. Samples for turbidity and pH analyses (a single 250 mℓ bottle per site) and bacteriological sample bags were stored in an ice chest.

The analytical schedule was set so that coliform analyses were performed immediately upon return to the laboratory. Bacteriological analyses were performed within six hours (freshwater) and four hours (marine) for TC and within four hours (freshwater) and two hours (marine) for FC. Laboratory procedures utilized are outlined in detail in Cowan (1980) and are summarized in Table 12. Marine systems immediately surrounding landed masses are subject to adverse impacts from rainfall; therefore, precipitation data were obtained (Table 13) from the National Weather Service.

RESULTS AND DISCUSSION

Marine Water Quality

Near shore marine water quality was examined in two of the seven disctrict centers of the TTPI (Koror, Palau and Kolonia, Ponape). The purpose of this investigation was to establish baseline data for the following pertinent parameters: bacteriological (fecal and total coliform); physical (turbidity, pH, water temperature, salinity and dissolved oxygen). A sampling regime such as the one undertaken in this research could only be accomplished with the close cooperation of the local environmental specialists. Logistic support, both on land and water, as well as availability of laboratory space and technical assistance from the Environmental Health Laboratory staff, represent the deciding factors for successful research/monitoring projects in these remote sections of the western Pacific Ocean.

Koror

During the period from 7 July to 30 July 1980, a total of 13 sampling trips was made to the marine waters surrounding Koror (Palau). The sample sites for both the marine and freshwater distribution systems are represented in Figure 2. The consistent problem areas in the marine system, areas which pose significant threats to public health, were concluded to be in the vicinity of T-Dock (sites 1, 4 and 5) and a small bay immediately adjoining the old Community Club and the OICC (Officer in Charge of Construction) Office (site 8). During each sampling period, children were observed swimming and playing in the waters east of T-Dock between sites 1 and 4. There were six actual and one possible Fecal Coliform (FC) violations (Table 14) quantified at these two sites in this study. This area should be posted as a "no swimming area" until such time that these waters are made safe for human contact type activities.

A total of 12 FC violations was measured at sites 1, 4, 5 and 8 (Figures 3, 4, 5 and 6 respectively) with an additional five possible violations (Table 14) out of 51 samples analyzed. Violations of the FC standard for marine TTPI Class B waters are counts $\geq$400/100 mℓ (Table 3). If a site has FC densities equal to or exceeding 400/100 mℓ, there exists a danger to the health of people who come in contact with the water at that particular site. The highest geometric mean FC counts were at site 8 (153/100 mℓ); this numerical value represents a low estimate since means were calculated utilizing minimum figures when data were in doubt (ie, readings of >111 and >120 on 8 and 12 December at site 8 were valued at 111 and 120 for purposes of geometric mean determination).

The high FC counts at site 8 were due to release(s) of raw sewage into the bay from the pump station overflow pipe near the OICC Office. When a pump failure occurred between that station and the sewage treatment plant (STP), the station was shut down and the raw sewage was allowed to overflow into the bay. These sorts of occurrances are symptomatic of poor operation and maintenance by Public Works. Since the Area Sanitarian was not aware of this overflow, it is imperative that better lines of communication be developed between the two departments so that the public can be notified when such obvious health risks occur.

Interpretation of the potential health hazards which exist in a water resource should be made on a sample by sample basis. If an individual value exceeds the water quality standard for coliform, the area from which that sample was taken is in violation. As violations are quantified, the public should be notified. If a number of analyses are performed at the same site during any one month, the geometric mean and geometric standard deviation can be utilized as secondary measures of pollutional potential of the resource for the sampling period. The geometric mean is the antilogarithm of the arithmetic mean of the logarithms of the data and the geometric standard deviation is the antilogarithm of the corresponding arithmetic standard deviation (zero datum in the case of coliform densities are evaluated as unity). Geometric standard deviation is that number, which when multiplied by or divided into the geometric mean will yield an indication of the distribution of the data. Although the geometric mean FC densities for the period of study were <400/100 mℓ (Table 14), a single deviation from the mean yielded ranges indicative of potential health hazards (site 1:7-735/100 mℓ; site 4:14-493/100 mℓ; site 5:11-342/100 mℓ; site 8:38-621/100 mℓ) at the T-Dock and Community Club sites.

Fecal Coliform densities for the remaining 11 sites (2, 3, 6, 7 and 9-15) were similar with FC geometric mean values ≤7/100 mℓ and individual sample values ≤121/100 mℓ (Table 14). Only one possible violation existed (site 9: 22 July). Geometric mean FC densities for the Malakal sites (9, 10, 11 and 13) are displayed in Figure 7. These values are typical of waters surrounding Koror.

Total Coliform (TC) data are presented in Table 15. The marine waters off T-Dock and in the bay by the old Community Club contained the highest TC counts. All FC:TC ratios for data collected at sites 1, 4, 5 and 8 on days when FC violations were recorded exceeded 0.20. This indicates that recent human and/or animal fecal pollution occurred on those dates and highlights the public health hazards. The figures depicting coliform densities have been superimposed over the precipitation bar graph for the study period. At sites 1, 4, 5 and 8, locations where significant coliform densities were quantified, no consistent relationship could be deduced between precipitation and densities.

Turbidity and salinity data for near shore marine waters surrounding Koror are presented in Tables 16 and 17. The numerous apparent turbidity standard violations (underscored data - Table 16) indicate that the ambient conditions quantified in the previous baseline study (Cowan and Clayshulte, 1980) were inadequately assessed for the following marine waters: east of T-Dock (sites 1 and 4); Komebail Lagoon (sites 2, 3 and 5); adjacent to the causeway to Malakal (sites 6 and 8); Iwayama Bay (sites 14 and 15). Each of these areas are shallow waters which can only be reached by boat at high tide (Table 18). Water depths at these sites were <1.5 meters (m) with waters receding to <1.0 m at low tide. Geometric mean turbidity values were ≤3.1 NTU for these sites (Table 16) and their waters were clear and had no observable color. The "high tide sites" are depicted in Figures 8 and 9 (superimposed over rainfall data). Except for the depression of salinity concentrations and elevation in turbidity values on 22 July (site 5, KA Dock: Figure 8) there was no consistent relationship between these data. The salinity values for all stations studied remained fairly constant throughout the study period and were within the range established for TTPI marine waters (Table 3: 32 ±3 ‰).

The remaining marine water quality data (pH, temperature, dissolved oxygen [(DO)] and sampling schedules) are listed in Tables 19 - 22. Measurements of pH, water temperature and DO were similar to those values quantified in the previous study (Cowan and Clayshulte, 1980). Occasional DO standard violations were recorded (Table 21) in the shallow depth stations, yet, as in the previous study, only minimum importance was attached to these apparent violations because of the clarity of the water and the fact that the geometric mean percent saturation data equalled or exceeded 85%.

Kolonia

As was the case in the Palau phase of this study (inoperative Environmental Health Laboratory boat), boat scheduling problems limited the number of marine sampling trips during the one month study period. Thirteen trips were made to the waters surrounding the district center of Kolonia (15 December 1980 to 9 January 1981). The sampling stations for both the marine and freshwater distribution systems are presented in Figure 10. Sites 6 (Mwalok channel northwest of Kolonia in the vicinity of the STP outfall) and 7 (east of Kolonia) from the previous baseline study (Cowan and Clayshulte, 1980), areas where high coliform densities have been recently documented, are also represented in Figure 10. The relevant data from this previous study (summarized in Table 5) as well as local data (summarized in Table 6) indicated a definite health hazard existed in the waters east and north of Kolonia with all other near shore marine areas (west and northwest of Kolonia) exhibiting potentially hazardous water quality conditions. In order to validate the suspected direct adverse impact of rainfall events upon water quality, field data are superimposed over the rainfall bar graph (data listed in Table 13). Peak rainfall events for the study period were 17 December (4.1 cm) and 30 December (4.0 cm).

Fecal and Total Coliform densites are listed in Tables 23 and 24 respectively. Since the waters sampled are all marine coastal Class B (Table 2), the Fecal Coliform standard (Table 3: <400 FC/100 mℓ) will be used as the absolute limit at or above which violations are quantified. It is noted that a power outage of sufficient duration to invalidate coliform data occurred on 31 December. Fifty-two of the 132 samples analyzed for FC were found to be in violation of the FC standard. Fourteen stations were analyzed: one had a single value above, five had geometric means above and two had geometric means just under the water quality standard (Table 23).

The near shore marine waters in front of the Ekilis Hotel and Kohler's Hotel were of poor quality bacteriologically with each station yielding 5 violations from 12 samples (Figure 11). Peak coliform densities coincided with peak rainfall events at the Ekilis site; this cause and effect relationship will be utilized to conclude that contamination is washed from the land to the surrounding waters and results in excessive public health hazard on or immediately following days experiencing rainfall events of similar magnitudes. At the Kohler site, a similar increase in FC density occurred only on 30 December. The increased coliform densities at these two sites were maintained for a longer interval following the second peak rainfall event (30 December) due to higher levels of sustained precipitation; note that no rainfall datum was available for 1 January 1981.

Marine waters opposite the Pohnpei Hotel showed similar yet delayed increases in coliform levels with peak rainfall events, and violations were quantified in the January samples (Figure 12). The FC datum for this site on 6 January is assumed to be in error as it seems incongruous relative to both TC datum (6 January) and surrounding FC/TC data (Figure 12). Proceeding from this assumption, all samples taken past 30 December (5, 6, 8, 9 January) were in violation of water quality FC standard. Following periods of sustained rainfall, these waters constitute a health hazard.

The remaining two sites depicted in Figure 12 (waters off the Nanmadol Hotel and the South Park Hotel) exhibited variable coliform densities with no FC violations. These low densities increased as a result of the major rainfall events but presented no hazard. Given higher precipitation levels, potential violations are possible. These two sites border on either side of the Pohnpei Hotel site (Figure 10); therefore, a problem area does exist below the Pohnpei Hotel on the land (i.e. septic tank leach field), and contamination is leached to the near shore marine environment under sustained high levels of rainfall. The FC:TC ratios exceeded 0.20 in all water samples off the Ekilis, Kohler's and Pohnpei hotels which exceeded the FC standard. These high ratios indicate recent contamination of the water resource by raw wastewater and/or animal fecal material.

The coliform densities at the Dekehtik site (Figure 13) were similar in magnitude and variability to those quantified in the waters off the South Park Hotel (Figure 12): no FC violations. The increase in coliform densities following the 17 December rainstorm was not reproduced on 30 December; no definite relationship between precipitation and water quality could be found at this station.

Five of 12 samples at the STP outfall site (Figure 13) were in violation of the FC water quality standard. In addition, it is possible that another violation occurred on 18 December (Table 23: >60 FC/100 mℓ). Given this number of violations (50% of samples tested) and the high densities encountered (18, 24, 30 December; 5, 9 January: Table 23), the waters in the vicinity of the STP outfall represented a public health hazard. The large increase in coliform levels measured at the outfall on 24 December (STP effluent discharge point) could be utilized to explain the increases in FC and TC densities at adjoining sites on the same date (ie. Dekehtik: Figure 13).

Fecal and Total Coliform data from the remaining district center marine water quality sites are depicted in Figures 14 and 15. These sites are north and east of Kolonia and their waters are extremely poor in quality. Seven of 12 samples analyzed at the Komwonlaid site (Figure 14) exceeded the FC standard. Coliform densities mirrored rainfall intensity and, as was the case at site 12 (Figure 10), there were increased coliform levels on 24 December. The waters off Komwonlaid (site 13) were adversely impacted by both STP discharges and contamination washed from the land (i.e. surface runoff and streams). Geometric mean FC density for this northern station was 402 FC/100 mℓ; the greatest density was measured on 18 December (Table 23: 12900 FC/100 mℓ).

Coliform levels east of the Fish Market (site 8: Figure 10; Figure 14) were directly impacted by rainfall events; seven violations were quantified (Figure 14). The air field causeway protected this site as well as the other eastern stations such that STP discharges did not adversely affect water

quality at these sites (i.e. no increase of coliform densities on 24 December). At the Fish Market site, the geometric mean FC density was 457 FC/100 mℓ for the 12 samples analyzed; the greatest density was measured on 19 December (12800 FC/100mℓ).

Moving south along the eastern edge of Kolonia, the coliform levels increased. In the marine waters off the commercial establishment operated by Carlos Etscheit (site 9: Figure 10), 80% of the samples taken were in violation of the Class B FC standard (Figure 15). The coliform densities were directly related to rainfall; the geometric mean density was 1035 FC/100 mℓ. As with the other stations in the area (Figure 10: sites 13, 8, 9, DS), it is not only the number of violations quantified but also the large densities measured which constitute grounds for serious environmental concern.

The highest coliform densities measured in this study were in the marine area immediately opposite the mouth of the Dewenne Stream (Figure 10: site DS). Nine of the 12 samples analyzed were in violation of the standard (Figure 15); the geometric mean of these data was 1344 FC/100 mℓ. Given sustained rainfall (i.e. 17-21 December; 30 December - 4 January: Figure 15), peak FC levels lagged behind the onset of the sustained rainfall (i.e. 17, 30 December). Under rainfall conditions, contamination is washed directly from the land into the near shore marine areas as well as into the stream itself. Given sustained rainfall patterns similar to those experienced in this study, coliform bacteria levels will increase at site DS (Figure 10) as contamination from a larger area (i.e. upstream) reaches the mouth of the stream. Given shorter duration storms, no lag period exists because peak coliform levels are a result of contamination input from the immediate vicinity.

The FC:TC ratios (geometric mean coliform values) for the north and east shore stations (Figure 10: sites 13, 8, 9, DS) were 0.79, 0.59, 0.80 and 0.54 respectively. These sites, and most probably the entire shoreline marine areas bounded by these sites, were contaminated by human and/or animal fecal matter. Based upon the indicator organism (FC and TC) data gathered in this study, only limited areas around sites 4 (off the Nanmadol Hotel), 5 (off the South Park Hotel) and 12 (off Dekehtik) were found to be free from high levels of bacteriological contamination.

Since it is hypothesized that material was washed from the land into the marine environment around Kolonia, turbidity data (Table 25) should substantiate this fact. The high turbidities recorded in this study exceed the recommended TTPI Class B standard (Table 3: ≤2.0 NTU). Utilizing geometric mean values, only sites 5, 12 and 14 met this standard (Table 25). The Pohnpei Hotel site (2.1 NTU) and the Nanmadol Hotel site (2.6 NTU) were the only other sites routinely measured whose geometric mean turbidity values approached the standard. This standard was developed utilizing a paucity of data, data which quantified the TTPI on an islandwide basis (Cowan and Clayshulte, 1980). It was noted in this previous study that the listed turbidity standards were: (a) subject to validation on a case by case basis as more data became available; (b) to be relaxed in certain areas during periods of heavy rainfall. In other words, as more data becomes available to more adequately quantify ambient conditions throughout the TTPI, that subsequent data would be utilized to establish a more relevant standard. These two conditions clearly refer to the marine waters around Kolonia. Sites 2, 3, 7, 8, 9 and DS had a geometric mean turbidity value of 6.9 NTU

and a geometric standard deviation of 2.0 for 67 turbidity measurements. Omitting data taken at these sites on or immediately following peak rainfall events (18, 30 December data: Table 25), geometric mean turbidity was 6.0 NTU (n = 56; geometric standard deviation = 1.7).

The highest turbidity values were measured off the north shore of Kolonia at the Komwonlaid site (geometric mean 14.6 NTU: Table 25). Omitting 18, 30 December data (n = 11; geometric standard deviation = 1.9), the geometric mean turbidity was 12.0 NTU.

Turbidity (Table 25) and salinity (Table 26) data are presented superimposed over rainfall data in order to graphically demonstrate any relationship between these water quality parameters and precipitation. Distinct decreases in salinity along with corresponding increases in turbidity occurred at or following peak rainfall events in the marine waters surrounding Kolonia. The inverse relationship between salinity and rainfall as well as the direct relationship between turbidity and rainfall is most clearly illustrated in Figure 16 (sites 8 and 9: east of Kolonia). The remaining east coast site (Dewenne Stream) as well as the high turbidity station off Komwonlaid are shown in Figure 17. The lag in the return to ambient salinity levels at site DS (Figure 17) as compared to sites 8 and 9 (Figure 16) indicated a larger input of freshwater at the stream site. The loss of coliform data (electrical power outage) on 31 December was unfortunate since the steep drop in salinity values on that date (Figure 16; Figure 17: Dewenne Stream site) indicate the potential for even higher levels of bacterial contamination than were quantified in this study (Figure 14: Fish Market site; Figure 15).

Salinity and turbidity data for the remaining sites are presented in Figures 18, 19 and 20. Geometric mean turbidity levels were 1.6 and 1.9 NTU respectively and salinity values remained relatively invariant at sites 12 and 14 (Figure 18). The South Park Hotel site had the lowest turbidity (highest clarity) water (Figure 19; geometric mean = 1.3 NTU). Salinity values varied between 19 and 34 $^{0}/_{00}$ for the hotel sites (Figures 19 and 20). In the waters west of Kolonia, generally higher turbidity values were measured off the Ekilis Hotel and Kohler's Hotel (Figure 20).

The other marine water quality data (pH, temperature, DO and sampling schedules are listed in Tables 27 - 30). Marine pH values (Table 27) were similar in magnitude and variability to those values quantified in the previous baseline study (8 - 10 January 1980; data summarized in Table 5). All stations measured had arithmetic mean pH levels of 8.0 ± 0.2 pH units. Marine water temperatures (Table 28) were generally lower than those measured around Kolonia in January 1980 (sites 6 and 7; arithmetic mean temperature 27.9°C, n = 6). The range of mean temperatures for the current study was 24.0 to 26.9°C with an arithmetic mean of all data (145 samples) equalling 26.4°C. Dissolved oxygen levels equalled or exceeded Class B standard (≥4.5 mg/ℓ) in all but two of the 145 measurements (Table 29). Geometric mean values at all stations were at or above 5.6 mg/ℓ with corresponding percent saturation values exceeding 81%.

Public Water System

The freshwater distribution systems in three of the district centers were evaluated. Due to funding, personnel and time constraints, it was necessary to limit the monitoring in Colonia (Yap) to a one week period. It is noted that only PWS samples were taken in this district center. The other two district center systems (Koror and Kolonia) were sampled in conjunction with the near shore marine water quality monitoring program herein reported. The systems in Colonia and Koror were operated intermittently with very limited morning and evening water hours; water hours were necessitated because public works could not meet demand requirements. The public water system (PWS) in Kolonia (Ponape) was the only continuously operational water purveyance system in the trust territories.

Minimum water quality monitoring requirements for the TTPI district center PWSs are given in Cowan (1980); for more detail, refer to this report or to TTPI (1978). Pertinent standards are summarized as follows:

i. $\leq$ 1 Total Coliform/100 mℓ as the arithmetic mean of all samples examined per month;
ii. $\leq$ 1 Turbidity Unit (TU) as determined by monthly averages;
iii. $\geq$ 0.2 mg/ℓ Free Residual Chlorine (FRC) at all times.

When less than 20 samples are analyzed per month, the coliform density should not exceed 4 TC/100 mℓ in more than one sample. Turbidity violations can also occur if two consecutive samples exceed 5 TU.

Colonia

The 10 sampling stations described in Cowan (1980) were utilized to define the distribution system in Yap; these sites are represented in Figure 21. The water treatment plant (WTP: site 2, Figure 21) experienced numerous operational difficulties during the summer of 1980 (study period 1-4 July) and was, therefore, doing a very poor job treating the raw water (surface water source - Gitam Reservoir): a) insufficient sand in filters (sand on order); b) inadequate residence times in coagulation/sedimentation chambers; c) booster pump operating at approximately 20% capacity (C. Dano, Water Division, Public Works [PW] Department, Colonia; personal communication, 1980). The pumping problems (new pump on order) resulted in a time reduction of the water hours (normally 0600 - 1200 and 1600 - 2300) to but 8 hours per day (0600 - 0900 and 1600 - 2100). The lack of treatment (conditions a and b) was reflected in the water quality data quantified in this study (Table 31). The low quality surface water (site 1: Figure 21) was not improved to meet drinking water quality standards on any of the four sampling days.

Water at delivery points in the distribution system (sites 3 - 10) had zero FRC in 27 of the 29 samples analyzed; all samples had excessively high turbidities (Table 31). Low solids removal at the WTP (PW had stopped using alum because it was not inducing solids removal) was measured with no removal quantified on 4 July (sites 1 and 2: Table 31; 200 NTU). Chlorination, a unit process practiced at the WTP, was verified by the presence of FRC in the WTP effluent (site 2). The effectiveness of chlorination is dependent upon the retention of a FRC level ($\geq$0.2 mg/ℓ) once adequate contact time has killed

pathogenic organisms. The high levels of silt and sediment (turbidity) consumed the FRC present in the WTP effluent such that FRC was essentially zero by the time the water reached the district center (sites 3-10).

The average coliform density for the distribution system (sites 2 - 10) exceeded the standard. It is noted that a power outage invalidated the 4 July TC samples. The TC densities measured in this study were conservative estimates of actual densities due to probable interference by high levels of silt and sediment. These high turbidities resulted in clogging of the membrane filter (MF) used in the coliform analysis such that: a) it was difficult to count the bacteria; b) the layer of dirt prevented the coliform bacteria from obtaining nutrients thus inhibiting colony development. This inhibition is demonstrated by the inverse results of getting higher growth given less sample (i.e. site 1 - WTP influent):

	date	aliquot, mℓ	count (TC)
i	7/2/80	10	55
		30	0
ii	7/3/80	10	TNTC (Too numerous to count)
		30	52

Turbidity interference can be minimized through utilization of the Multiple Tube Fermentation Analysis for MPN (most probable number). Regardless of the lower accuracy of the MF technique, the Colonia PWS was in violation of drinking water standards for coliform, turbidity and residual chlorine.

Koror

The PWS in the district center of Palau was sampled on 12 separate dates during the period from 8 July to 1 August 1980. Sample locations, presented in Figure 2, included three Airai locations (site 1: WTP influent - surface water source; site: WTP effluent; site 3: watermaster's house adjacent to the WTP). Water is diverted from the distribution system and directed through an independent treatment scheme at the Continental Hotel; therefore, this station (site 4) will be discussed separately from the Koror PWS distribution network. For purposes of data analysis, PWS distribution sites are numbers 2, 3, 5-13. Excessive demands (water wasteage included) and/or the existence of major leaks in the distribution system (water losses) resulted in restrictive water hours (0600 - 0800 and 1800 - 2000). As was the case in Colonia (Yap), sampling schedules did not coincide with regular work hours at the District Sanitation Laboratory; therefore, work periods were adjusted so as to make PWS sampling possible.

Indicator organism (Total Coliform) data are presented along with FRC and turbidity data in Tables 32 a, b and c. On days when logistics could prevent PWS sampling, it was suggested that various members of the hospital staff (Macdonald Memorial Hospital houses the District Sanitation Laboratory/Offices) could bring in culinary water samples (utilizing proper procedures so as not to contaminate samples) for drinking water quality analysis. During the study period, six such samples were analyzed (data not listed in Table 32 a) and all measured zero TC/100 mℓ. Including these data, 114 samples were analyzed for

TC and the arithmetic mean density was 1.3 TC/100 mℓ (standard ≤1 TC/100 mℓ). Nine samples had counts exceeding 4 TC/100 mℓ (standard: given 20 or more samples per month - coliform density should not exceed 4 TC/100 mℓ in more than 5% of the samples); the standard allows 6 samples to exceed this level. Fifteen of the 114 samples had FRC<0.2 mg/ℓ (includes three violations from hospital staff home culinary water samples). Heavy chlorination was practiced at the WTP (Table 32 b: site 2 - FRC) and, of the 15 samples in violation of the FRC standard, only four had coliform counts >4 TC/100 mℓ (8 July: sites 10 and 12; 9 July: site 12; 28 July: site 13). The Meyuns site, located at the end of a branch line of Arakabesan (Figure 2: site 12), had the poorest quality water (four violations of bacteriological drinking water standard: 8, 9, 10, 14 July - Table 32 a) as well as the most erratic water service. Although the station was on the sampling schedule (Table 33 a), it did not receive water service on three of the days when the PWS was sampled (16, 21, 25 July).

The Koror PWS was in violation of drinking water coliform standards; this violation, although serious, was not as much of a consistant problem to culinary water supplies as was turbidity. The arithmetic mean (geometric mean) turbidity level for the PWS distribution network was 7.4 NTU (6.7 NTU) with a standard deviation (geometric standard deviation) of ± 3.5 NTU (1.53) for a total of 115 samples. Only 30 samples had turbidities ≤5 NTU with the lowest recorded turbidity being 3 NTU. It is reiterated that the turbidity drinking water standard is ≤1 NTU. It is noted that for the same period that the geometric mean turbidity for the near shore marine waters surrounding Koror was 1.5 NTU (Table 16).

The remaining water quality data (specific conductance, pH) and the sampling schedules are listed in Tables 33a,b and c. Specific conductance, a measure of the ability of the sample to conduct electric current, is present in water due to the presence of dissolved ionic species. Levels of total dissolved solids, as indicated by conductance, are safely within accepted drinking water standards. The hydrogen ion concentration, as quantified by pH, was relatively invariant; arithmetic mean station values ranged from 7.6 to 8.1 pH units.

Four coliform standard violations were measured at the Continental Hotel during the study. A break in the line between the main distribution system and the hotel occurred on or shortly prior to 23 July 1980. This contamination was indicated (Table 32 a: site 4, 23 July, >145 TC/100 mℓ) yet not confirmed in the follow-up samples taken on 25 July (0/0 FC/100 mℓ). The slash notation for this site represents the fact that two samples were taken: washroom sink/kitchen sink (25, 29, 30, 31 July; 1 August). Contamination was confirmed on 28, 29 July and the hotel management was instructed by the District Sanitation Safe Drinking Water Specialist (L. Abraham) to take health safety precautions with regards to all culinary water. The management posted warnings that during the hazardous period, all drinking water should be boiled prior to consumption. Chlorination levels at the hotel treatment plant were increased in order to insure removal of any hazard (FRC values exceeded 1.8 mg/ℓ in six samples taken on the last three sampling dates - 30, 31 July; 1 August : Table 32b). During the emergency period, the only time that FRC levels were less than 0.2 mg/ℓ was on 29 July (washroom sink). The hotel management and staff responded rapidly and efficiently to remove this health hazard. It is noted that a single violation occurred on 9 July when the accompaning FRC level was less than 0.1 mg/ℓ (Table 32b).

Kolonia

The WTP influent (site 1A) and nine distribution network stations (sites 1B, 2, 3, 6 - 10, PH) in the district center of Kolonia were sampled on a regular basis during the study period (13 December 1980 - 10 January 1981) on Ponape. The site locations are given in Figure 10. A single trip (10 January) was made to the branch line termini on Sokehs (Ngatik and Danpei); these data will be included in the Kolonia PWS evaluation. The Village Hotel water was examined on two consecutive dates (2, 3 January) and will be discussed as a separate entity as it is an independent water system.

Numerous coliform violations were quantified in the Kolonia PWS during the study period; these data (TC, FC and FRC values) are presented in Tables 34a, b and c. The dashed lines indicate that no datum was measured. Fecal Coliform (FC) analyses were performed initially at all sites sampled (13 December) and subsequently on samples at those stations where contamination was suspected to be present (i.e. when a TC growth was observed in the preceding sampling). Of the 108 TC analytical measurements quantified, nearly half of the samples (50) were in violation of the TC standard (i.e. > 1 TC/100 mℓ). Negative results were observed in 41 samples and the remaining 17 samples had counts of 1 TC/100 mℓ. The arithmetic mean (geometric mean) TC density was 8.4 TC/100 mℓ (2.7 TC/100 mℓ) with a standard deviation (geometric standard deviation) of ± 22.4 TC/100 mℓ (3.78). The number of TC violations and the magnitude of these mean values indicate the presence of a health hazard to the public consuming freshwater from the Kolonia PWS.

Residual chlorine (FRC) levels equalled or exceeded 0.2 mg/ℓ in 92 of the 108 analyses performed; twelve of the 16 FRC violations were accompanied by TC violations. High levels of chlorine were added at the WTP (site 1B, FRC levels: Table 34c) and all measurements of WTP effluent equalled or exceeded 1.8 mg/ℓ except the 18 December datum: the FRC level decreased to a minimum measured value (since continuous monitoring was not practiced, the minimum value could have gone unrecorded) of 1.0 mg/ℓ. It is hypothesized that FRC levels did go below this level at the WTP since six of the eight readings taken in town were ≤0.1 mg/ℓ (Table 34c: 18 December FRC). It is noted that this date was one day after the onset of the first of two peak rainfall events experienced in the study period.

The excessive public health danger could not possibly be overstressed given FC bacteria presence in a PWS. Four positive FC assays were quantified in the Kolonia system. Three of these four were measured on 18 December, a date on which only three PWS network FC analyses were performed. This insufficiency of water quality data as well as an absence of WTP operational data precludes any statement other than the system failed on this date and an excessive health hazard did exist in Kolonia.

Turbidity and pH data are presented in Tables 35a and b; pH values were invariant and mean station levels (except Ngatik and Danpei) ranged from 7.6 to 8.3 pH units. More data must be collected in order to validate pH values at the two Sokehs sites. Turbidity levels in the raw water (site 1A) and in the processed water (except sites 6 and 7) followed peak rainfall events; maximum levels were reached on 17, 18, 31 December and 2 January. Sixteen of the 29 turbidity violations (> 1.0 NTU) occurred on those four days; all nine network samples taken on 18 December exceeded the water quality standard. Whereas the

arithmetic mean ± standard deviation turbidity value for all PWS network data (n = 108) was slightly above the standard (1.1 NTU ± 0.55 NTU), the geometric mean value met the standard (0.96 NTU; geometric standard deviation = 1.5).

Specific conductance and sampling schedule data are listed in Tables 36a and b. Conductance values indicate lower total dissolved solids than were present in the Colonia and Koror systems. As was the case in these two PWS's, dissolved solids values were well within drinking water standard levels.

Previously recorded data collected by the District Sanitation Laboratory staff (Table 10) indicated very serious coliform bacterial contamination in the community water system supplying the Village Hotel. The Kolonia water quality monitoring program (PWS/marine system) precluded regular sampling at this hotel; however, two sampling trips were included on 2, 3 January. High TC levels on 2 January were increased by an order of magnitude in the 3 January sample; on this second date both Total (360 TC/100 mℓ) and Fecal (1600 FC/100 mℓ) Coliform analyses were performed. These high levels were accompanied by zero FRC levels on both dates. Turbidity values were roughly four times those quantified in the Kolonia PWS (Table 35a: 4.2 NTU, average turbidity; n = 2).

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

District Environmental Health Laboratory water quality data from Koror (Palau) and Kolonia (Ponape) were collected and collated. This material has been presented in the Literature Review Section: near shore marine areas surrounding the district centers - Koror (Table 4) and Kolonia (Table 6); public water systems - Koror (Tables 7 and 8) and Kolonia (Table 9). In addition to the data gathered by the local technicians, the review section contains summaries of relevant data from the previous baseline study (Cowan and Clayshulte, 1980) of the marine environments surrounding Koror (Table 1) and Kolonia (Table 5).

An integral portion of the project involved working directly with local laboratory staff personnel. This afforded an excellent opportunity to supplement water quality sampling, laboratory analytical and data handling skills. Training programs are administered by the Trust Territory Environmental Protection Board (TTEPB) in Saipan; it is imperative that this authority be consulted whenever independent agencies offer training programs to district technicians. The best form of training is on site, in the local labs, utilizing equipment and supplies available and in daily use at the local laboratory. Local technicians were gradually integrated into the sampling and laboratory programs. Initially, the local specialists would observe; gradually, the work load and responsibilities were shifted such that at the end of each phase, the local technicians had experienced all aspects of the program.

Marine System

The primary objective of this study was to establish marine baseline water quality data for the district centers of Koror and Kolonia; this information is presented in the Results and Discussion Section. It has been recommended (Cowan, 1980) that a minimum of two sampling trips per month be made to a selected number of sites, sites which will adequately cover the district center area as well as evaluate known hazard areas.

Coliform ratios have been utilized to indicate recent raw wastewater pollution of a water resource - Fecal Coliform:Total Coliform (FC:TC) ratios ≥ 0.20. In the case of Micronesia, where numerous pigs and chickens inhabit areas bordering the aqueous environment (stream banks and island shores), high FC densities could be either human and/or animal in origin. In order to discern the source of fecal pollution, a different bacterial ratio can be used - Fecal Coliform:Fecal Streptococci (FS). The FC:FS ratios are different for human and animal feces. The water resource is sampled and analyzed for the biological parameters FC and FS. Given ratios (FC:FS) > 2, the source of contamination is human; given ratios < 1, the source is animal; ratios in the range of 1 to 2 are unknown as to the source of contamination.

Future water quality research projects should include the FS analysis in addition to the standard FC and TC tests in order to identify sources of fecal pollution. Such data will enhance the validity of predictions as to potential for environmental improvements in water quality given operational wastewater treatment systems. If contamination is concluded to be animal in origin, appropriate animal management practices should be invoked.

Koror

Marine waters of poor water quality (and therefore representative of areas where improvement in water quality should be manifested upon completion of an operational wastewater collection system) existed in the area of T-Dock: sites 1, 4 and 5. This area should be posted as a "no swimming area"; water contact activities in and around the T-Dock section should be limited to the high tide pool at the north end of the dock.

The high coliform densities measured at site 8 (small bay adjoining the Community Club) demonstrated that a public health hazard did exist during the study period. Assuming that these poor conditions were due to the sporatic dumping of raw sewage into the bay through an overflow pipe at the pump station adjacent to OICC, marine water quality can be improved by better system operation and maintenance at Public Works (PW). It is recommended that future failures in the sewage pumping system should be reported by PW directly to the District Sanitarian such that: A) area can be posted as hazardous - "direct sewage spill area; swimming/water contact prohibited"; B) area can be sampled regularly until the Fecal Coliform densities return to ambient (safe) conditions. These spills represent direct injections of raw (untreated) sewage which must be prevented or at least managed so that human health is preserved.

Kolonia

The near shore marine water quality in the areas surrounding the district center of Kolonia was extremely poor; numerous marine coastal Class B standard violations were measured for coliform bacteria and turbidity. Regions of greatest contamination were those waters lying off the north and east shores of Kolonia. The entire near shore marine environment bordering this district center should benefit from complete implementation of a functional wastewater collection/treatment/disposal system. In marine regions directly impacted by freshwater inputs (i.e. streams), contamination from a wide area is washed into the stream and eventually into the marine environment. Until all upstream inhabited areas are sewered, the "estuarian" zones will remain a water quality problem.

Given a functional wastewater treatment system, the waters in and around Kolonia will still suffer from heavy silt/sediment loadings during and after periods of significant rainfall. In other words, turbidity and all its directly adverse impacts will remain water quality problems in and around this high island regardless of the status of the wastewater treatment system.

Due to the total absence of free residual chlorine (FRC) and the existence of numerous FC violations at site 14 (Sewage Treatment Plant [STP] Outfall), it is recommended that the operation of the STP be studied so as to improve overall plant performance. Chlorination should be instigated or current application practices improved such that sufficient contact time is utilized to kill bacterial populations. Coliform levels should then meet discharge standards and the subsequent mixing of STP effluent with receiving waters (Mwalok channel) should offer dilution factors necessary to decrease FC densities in the area of site 14 below water quality standard levels (<400 FC/100 mℓ).

Public Water System

The highest priority water quality monitoring program in Micronesia is the thorough and continuing evaluation of the public water system (PWS). When freshwater is supplied to the general public, those providing this service must insure that safe, high quality drinking water is delivered to all points in the service area. In the micronesian trust territories, this valuable function is performed by Public Works (PW). The surveillance function is directed by an environmental protection board (TTEPB, Saipan) and the monitoring is performed locally in the district centers by the District Environmental Health Laboratory. These two agencies (PW and Environmental Health) are independent of each other and communication between them is slight. The first recommendation with respect to the PWS is the immediate development of a strong working relationship between PW and Environmental Health; the establishment of a partnership rather than an adversarial posture. If there is a breakdown in the PWS, then PW informs Environmental Health which advises the public and monitors the troubled area.

Water treatment plants (WTPs) and water distribution systems have been developed and designed on the basis of continuous, 24 hour service. The Colonia (Yap) and Koror (Palau) PWSs are not functioning on this basis. Since the integrity of the distribution system is suspect in both district centers, it is recommended that all culinary water be boiled for at least 15 minutes in these locations. Water quality data, collected at various representative points in these two distribution systems, should be utilized to validate this recommendation in Colonia and Koror.

In districts where water hours are in effect and do not coincide with Environmental Health Laboratory work schedules, the appropriate Area/District Sanitarian should adjust selected personnel work hours such that complete distribution system sampling goals can be accomplished.

Conversion of the Yap and Palau district center PWSs from interrupted to continuous service should be the primary objective for system management. The possibility of leaky mains and laterals is a reality; however, since the replacement of all old mains and laterals is economically difficult if not impossible, alternative solutions must be found. As a first step towards a possible solution, education/conservation programs should be initiated in these (and all other partial service) district centers. People should be informed that water shortages result from wasteful water use practices and are specifically due to: A) outside taps left running during water availability periods; B) leaky fixtures. The education process should be directed by local sanitation officials; high school and college students would be ideal program assistants. Since the micronesian trust territories are currently moving toward more democratic forms of government, conservation would make an excellent political issue. Successful solution to this problem with the eventual goal of continuous water service would benefit all in the service area.

The PWS in Kolonia (Ponape) is, for the most part, a continuous system. During periods of such service, PWS water quality data should be utilized to justify confidence, or lack there of, in the system.

Colonia

Only a very limited amount of data were collected during the brief study period on Yap. Consultations with the Chief District Sanitarian and the Director of PW confirmed to the author that the Colonia system was operating as well as could be expected given all existing constraints. These two department heads are well aware of the near catastrophic conditions which exist in their PWS: A) restrictive water hours; B) excessive turbidities in process water; C) negligible FRC levels and high TC densities in distribution system. The small amount of information (Table 31) collected on this system verified the recommended public health precaution of boiling all culinary water supplies in Colonia.

A water conservation program has been initiated in the Colonia area (C. D. Jordan, District Planning Officer, Yap District; personal communication, 1980). High school students were enlisted to perform a house to house survey to quantify amounts of water wasted because of leaky fixtures.

The excessive turbidity levels present in the Colonia PWS inhibited the growth of coliform bacteria on the membrane filter (MF). Given high levels of silt and sediment in the sample to be tested, it is recommended that the Multiple Tube Fermentation technique be utilized to quantify coliform bacteria.

Koror

The evaluation of water quality data yielded confirmation that this PWS was in violation of the coliform and turbidity drinking water standards. Culinary water should, therefore, be boiled prior to use. The future expansion plans at the Airai WTP include obtaining increased raw water sources as well as the addition of coagulation/flocculation/sedimentation unit processes to the treatment train. These improvements, coupled with implementation of water conservation policies, should result in the continuous supply of high quality potable water to the Koror populace. The new solids removal processes will eradicate the turbidity problem thus making existing chlorination practices sufficiently efficient to guarantee complete absence of pathogenic organisms in the distribution system.

During those periods when system sampling is not possible, arrangements should be made for selected members of the hospital staff to bring culinary water samples from their respective homes to the laboratory for analysis. Selection of participating personnel should depend upon their home locations so that the system is representatively sampled. The Safe Drinking Water Specialist should train these personnel in the correct sampling procedures.

Kolonia

The PWS in this district center was operating on a continuous (24 hour) schedule. The bacteriological examination of the distribution system produced numerous TC standard violations. The magnitude of the mean TC density as well as the presence of four positive FC analyses provided the basis for the recommendation of precautionary boiling of all culinary water in Kolonia. Only

consistently negative indicator organism assays can provide evidence for removal of this restriction. Turbidity levels were at the standard threshold (1.0 NTU) and FRC values were sufficiently adequate to indicate only occasional system failure. Elimination of chlorination process failure should provide the solution to the problem of sub-standard drinking water quality.

The final process at a WTP is disinfection. At Kolonia, the chlorination system, as observed in this study, was inadequate and was therefore susceptible to operational failures and incomplete treatment. This process should be studied and evaluated with the primary objectives being: A) improvement of the chemical mixing; B) increased residence time in the contact chamber. Once the mechanics of the chlorination operation are functioning, correct chlorine dosages can be determined through experimentation at the WTP.

The WTP should be closely monitored during periods of sustained rainfall (i.e. most water quality violations occurred on 18 December, the day following the onset of the first major rainfall event of the study period). Particular attention should be directed toward diversion of excess quantities of raw water (flow equalization) prior to its entering the WTP. If the increased influent water volumes are not diverted, those unit processes which rely upon maintenance of designated flow through velocities (presedimentation), design hydraulic loading rates (filtration) and adequate residence times (presedimentation; chlorination) will not perform their respective functions.

ACKNOWLEDGEMENTS

This research was performed in the micronesian trust territories during the period of its most recent political transformation. A project involving so many separate agencies and governments could not have been possible without the concerned efforts of a great number and diversity of people. First of all, I would like to thank Mr. Nachsa Siren (Executive Director, TTEPB) for his guidance in aligning logistic as well as manpower support in Yap, Palau and Ponape.

In Colonia, Mr. Kloulubak Philip (Chief District Sanitarian) coordinated the Yap phase of the study. A special thanks to Mr. Vicent Mareyeg (Technician) for his diligent efforts both in the field sampling and laboratory analyses.

Mr. Haruo Remeliik (Deputy District Administrator) directed operations on Palau and was responsible for project approval in Koror. Mr. Tokiwo Sumang (Area Sanitarian) coordinated the logistic support and arranged personnel schedules. The marine system was sampled with the help of Mr. Thomas Borja (Technician) and Mr. Florencio Yamada (Water Pollution Specialist); Mr. Lucio Abraham (Safe Drinking Water Specialist) assisted in the freshwater distribution system sampling. Both Mr. Yamada and Mr. Abraham receive my special thanks due to their tireless efforts in the laboratory; in the latter stages of the Palau phase of this study, they performed all sampling and analytical tasks.

The last portion of the study was completed in Ponape. Mr. Carl Danis (Area Sanitarian) was responsible for our operations, both in the field and in the laboratory. Mr. Winston Likaksa (Water Pollution and Safe Drinking Water Specialist) helped in all aspects of the Kolonia phase of the study; without his hard work this part of the project could not have been completed. Marine logistic support was supplied by Mr. Richard Kroft (Marine Resources).

I would like to express appreciation to the Office of Water Research and Technology which funded this research and to the staff of the Water and Energy Research Institute whose concerted effort offered considerable guidance. Specifically, I would like to thank: Dr. Stephen J. Winter (Director, WERI) for overall project supervision; Mr. Russell N. Clayshulte (Research Associate, WERI) for data collection in Ponape and for text graphics; Mrs. Evelyn Q. Paulino and Rita Nauta for manuscript preparation.

LITERATURE CITED

American Public Health Association. 1975. Standard methods for the examination of water and wastewater, 14 ed. APHA, Washington, D.C., xxxix + 1193 p.

Cowan, P. A. 1980. Future water quality monitoring priorities for the Trust Territory of the Pacific Islands. Univ. Guam WRRC. Tech. Rept. 16. 61 p.

Cowan, P. A. and R. N. Clayshulte. 1980. Marine baseline water quality of the Trust Territory of the Pacific Islands. Univ. Guam WRRC. Tech. Rept. 14. 116 p.

ORSANCO Water Users Committee. 1971. Total coliform: fecal coliform ratio for evaluation of raw water bacterial quality. JWPCF 43 (4):630-641.

Trust Territory of the Pacific Islands. 1978. Territorial register, volume 2, number 8.

Trust Territory of the Pacific Islands. 1979. Task force report on point and non-point sources of pollution in the TTPI. Environmental Protection Board, 82 p.

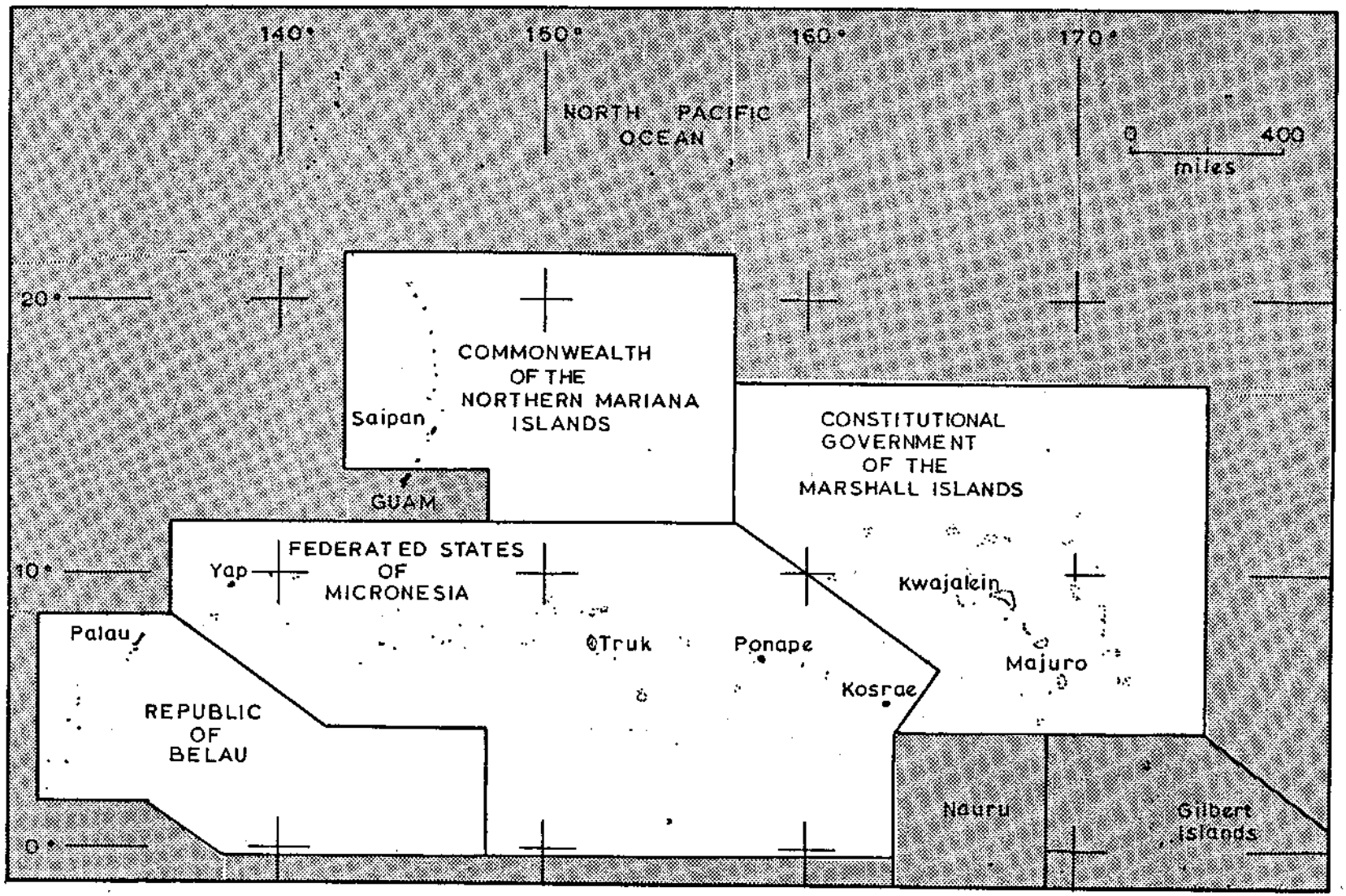

Figure 1. Micronesia and the new political boundaries of the Trust Territory of the Pacific Islands (TTPI).

--1-- Freshwater distribution system and sampling sites

① Marine water sampling sites

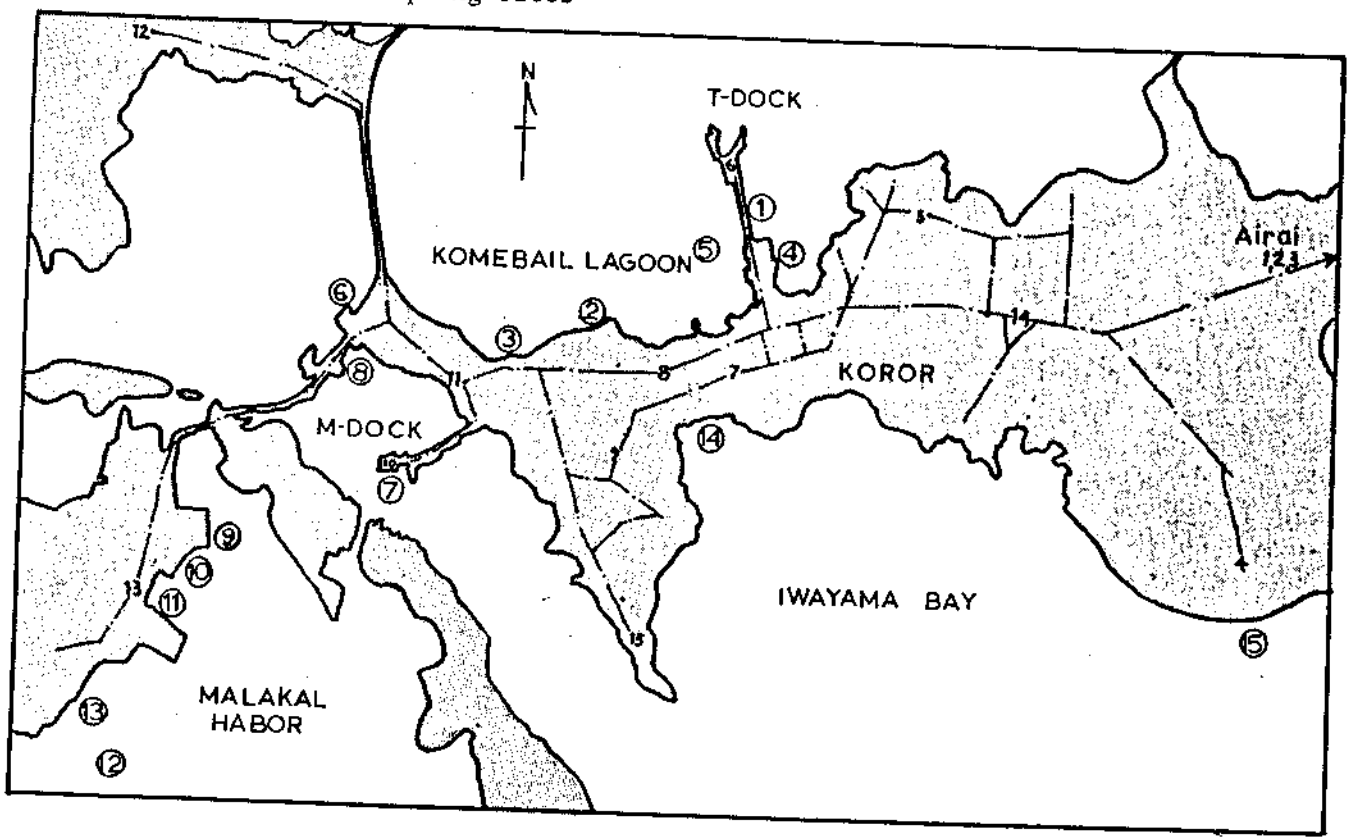

Figure 2. Marine water quality and freshwater distribution sampling sites Koror, Palau.

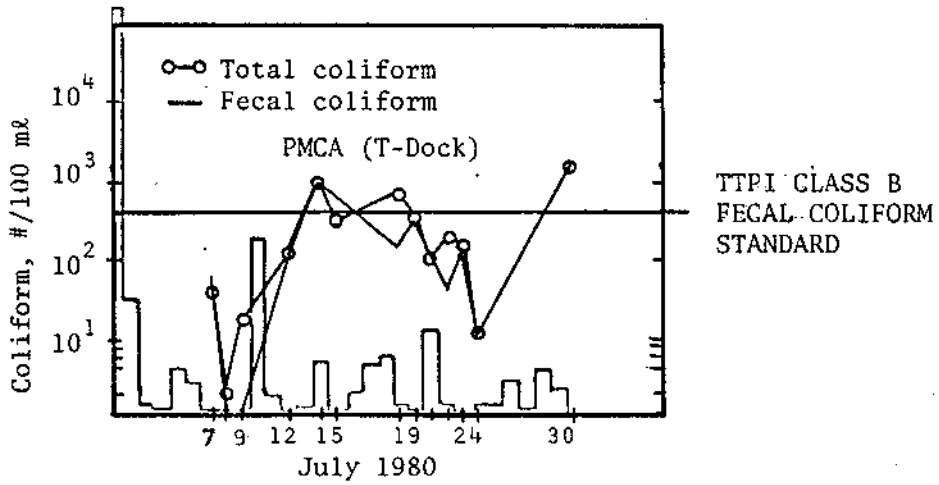

Figure 3. Marine fecal and total coliform at PMCA, T-Dock (Koror).

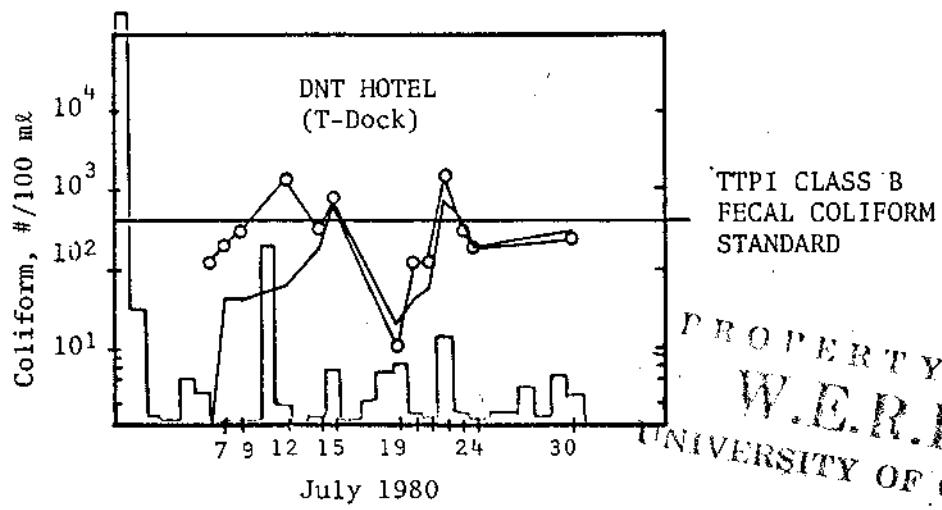

Figure 4. Marine fecal and total coliform at DNT Hotel, T-Dock (Koror).

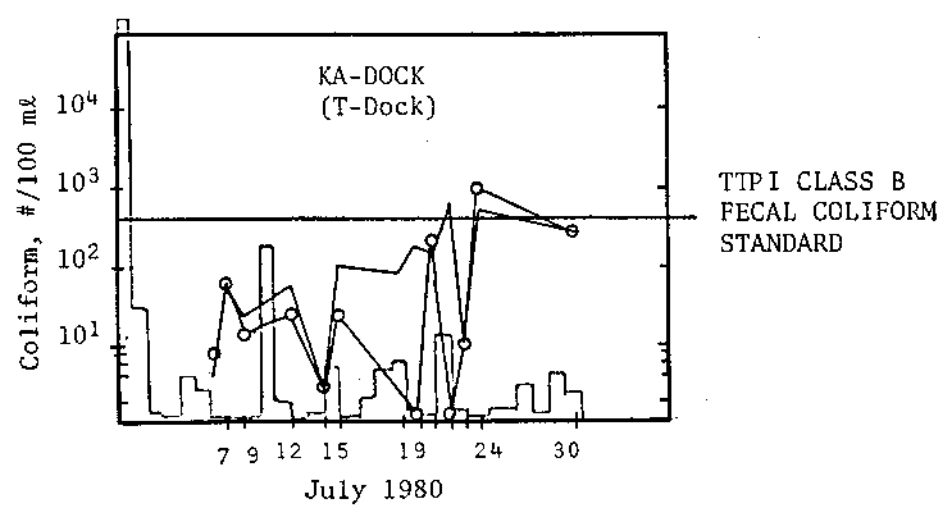

Figure 5. Marine fecal and total coliform at KA-Dock, T-Dock (Koror).

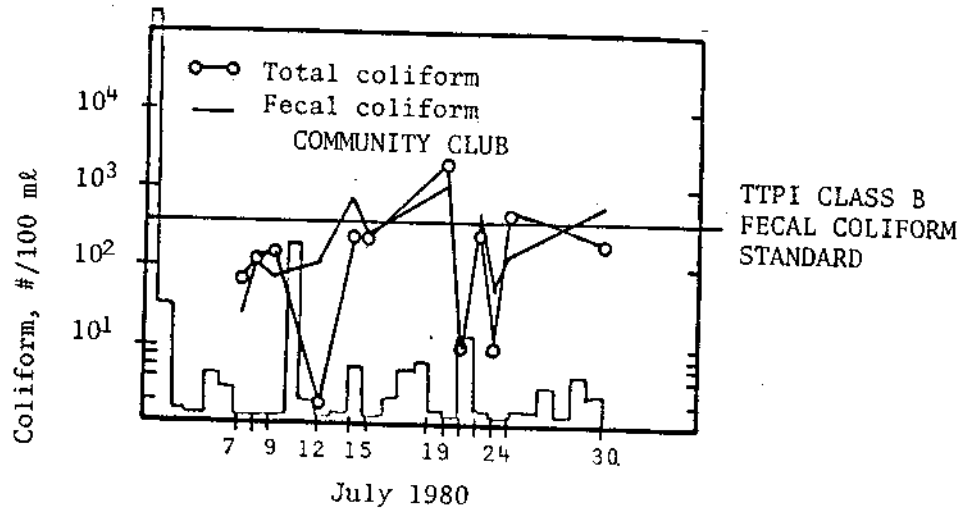

Figure 6. Marine fecal and total coliform at Community Club (Koror).

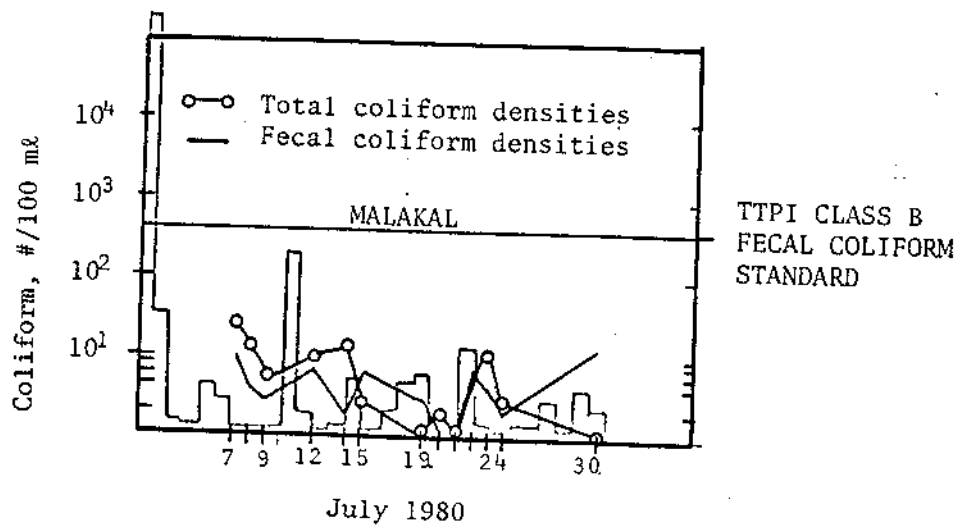

Figure 7. Geometric mean marine fecal and total coliform at Malakal (Koror).

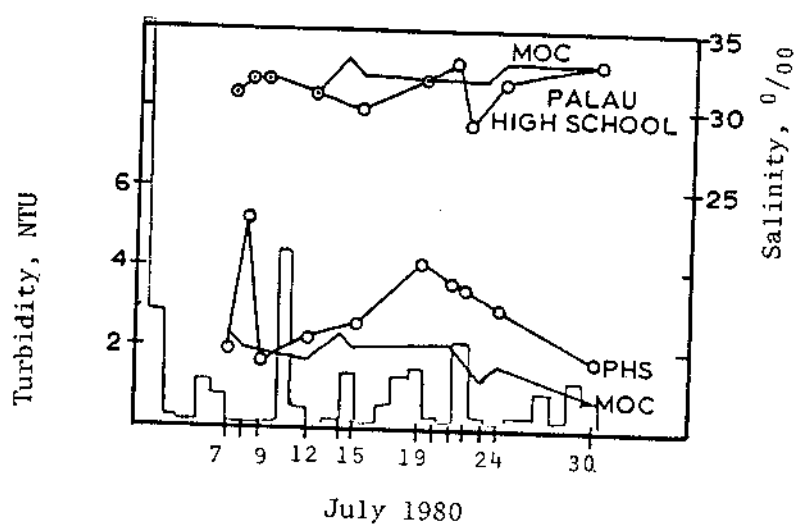

Figure 8a. Marine turbidity and salinity at T-Dock and Komebail Lagoon (Koror).

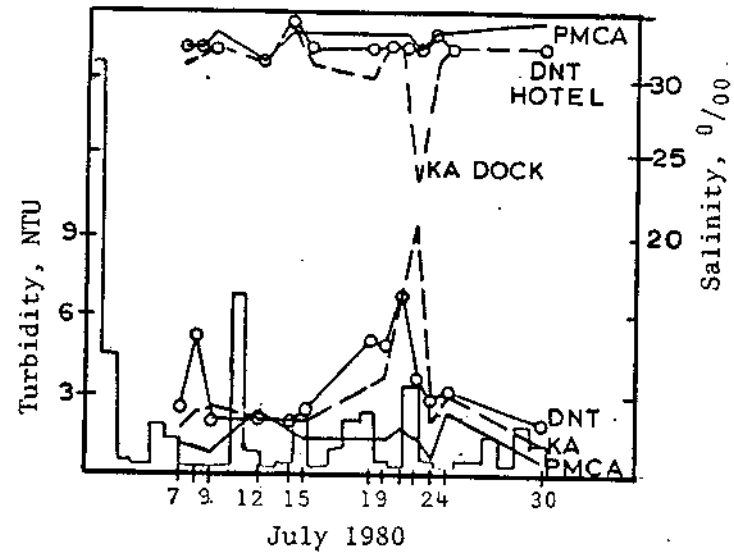

Figure 8b. Marine turbidity and salinity at T-Dock and Komebail Lagoon (Koror).

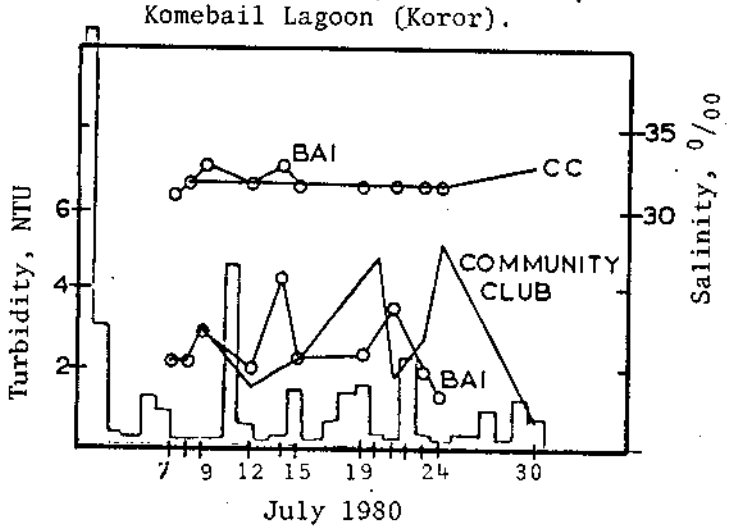

Figure 9a. Marine turbidity and salinity at causeway and Iwayama Bay (Koror).

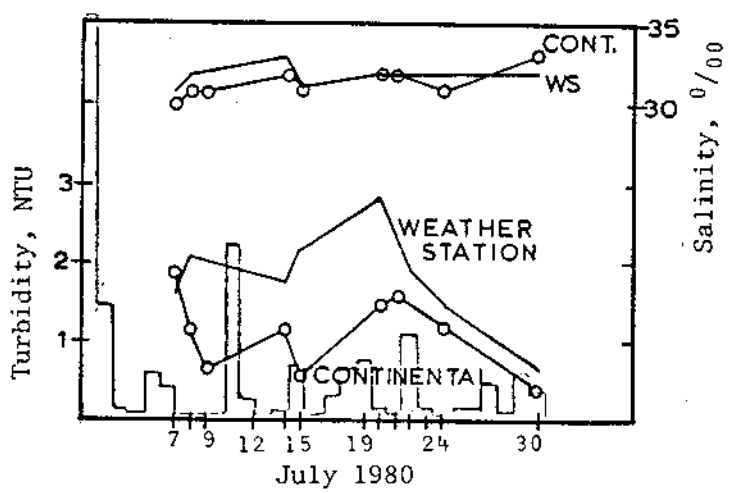

Figure 9b. Marine turbidity and salinity and causeway and Iwayama Bay (Koror).

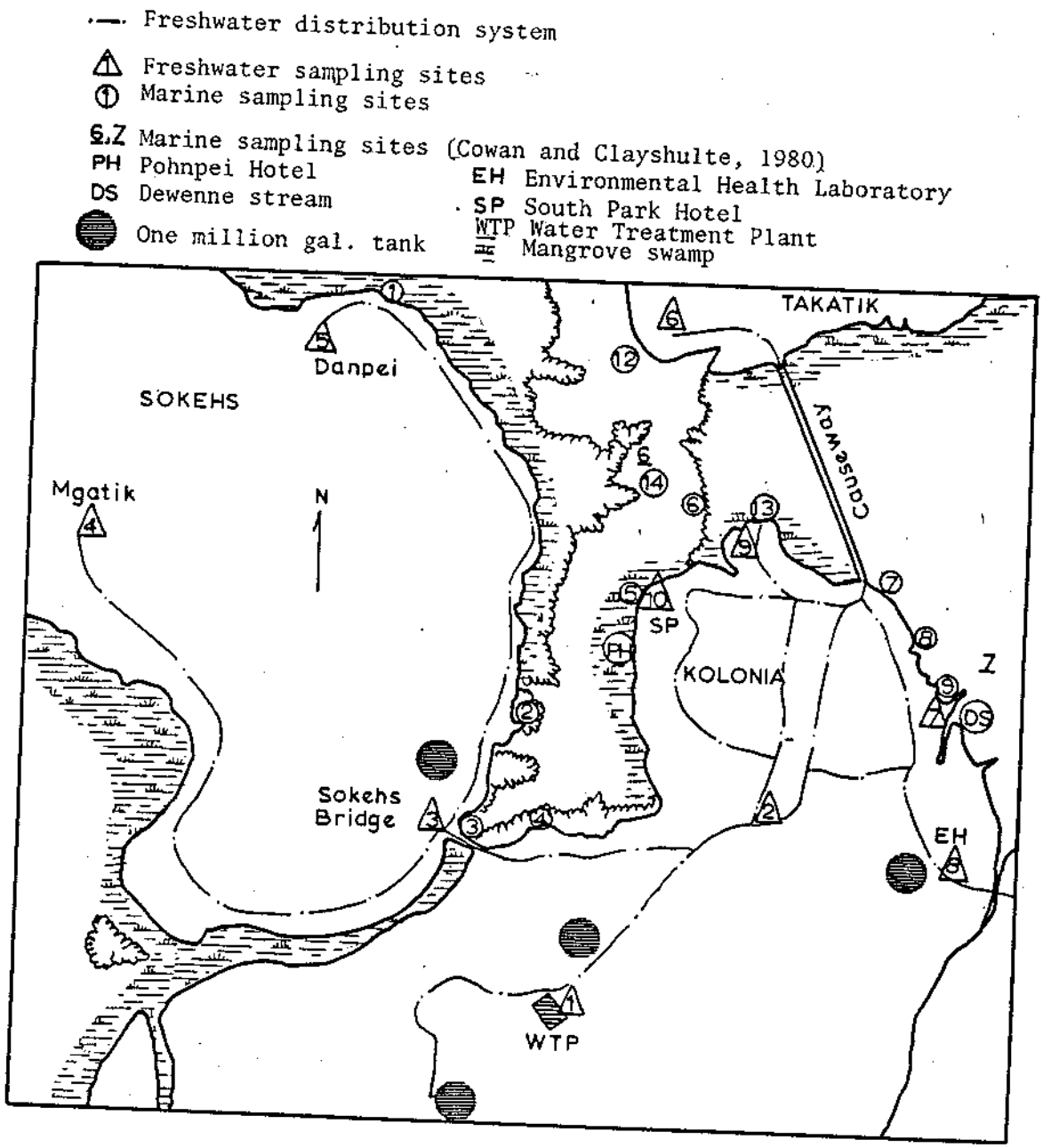

Figure 10. Marine water quality and freshwater distribution sampling sites Kolonia, Ponape.

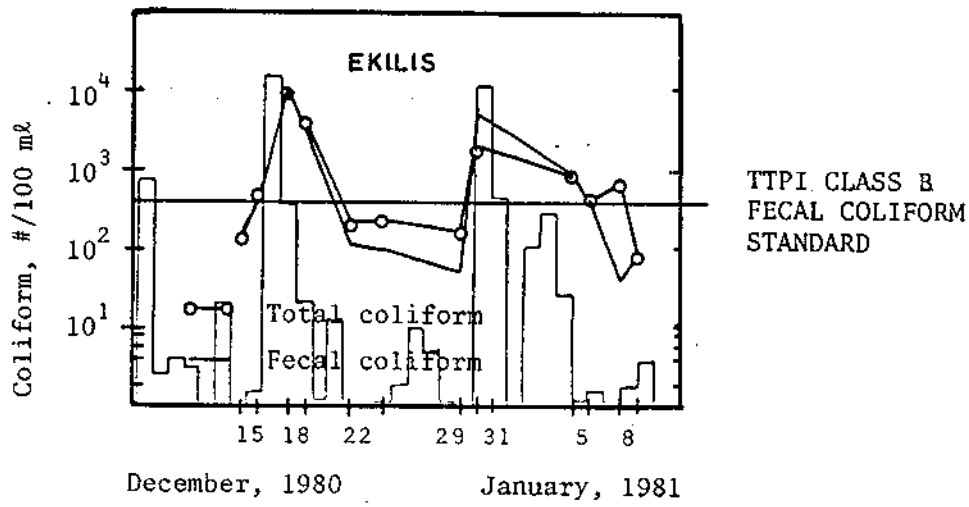

Figure 11a. Marine fecal and total coliform at Ekilis Hotel (Kolonia).

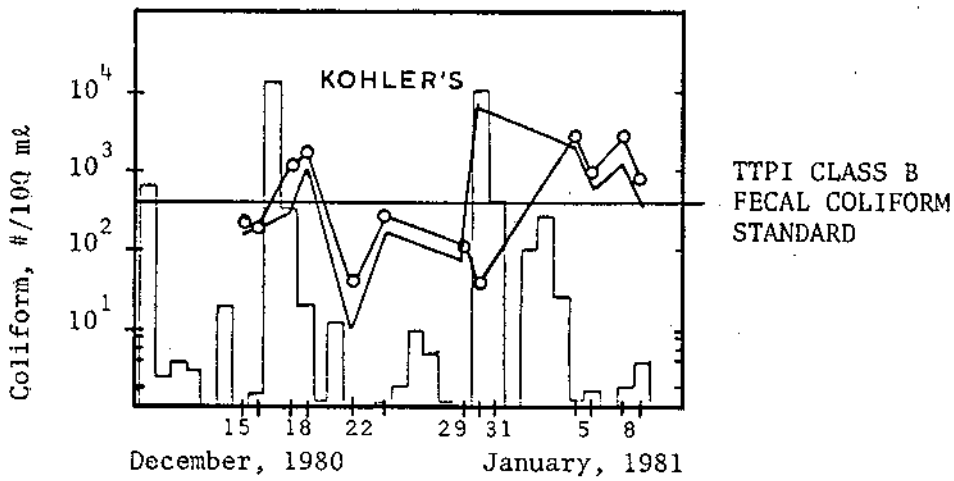

Figure 11b. Marine fecal and total coliform at Kohler's Hotel (Kolonia).

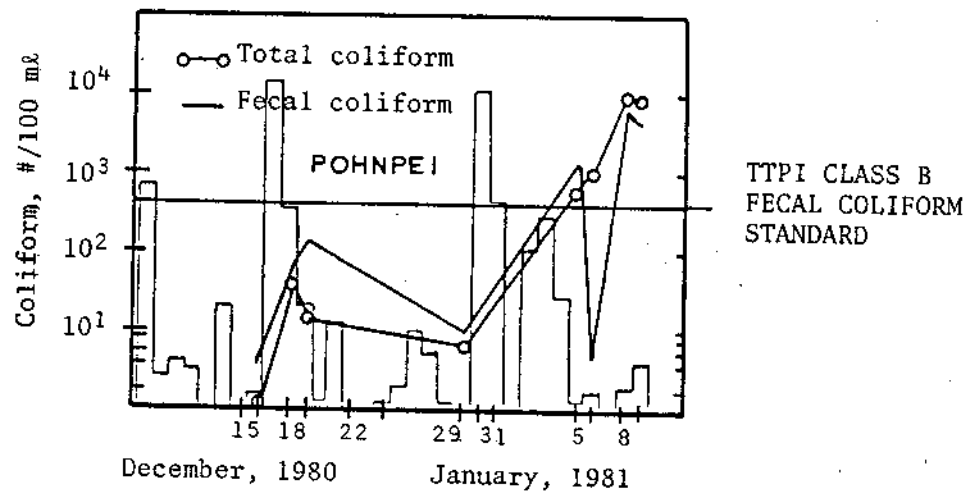

Figure 12a. Marine fecal and total coliform at Pohnpei (Kolonia).

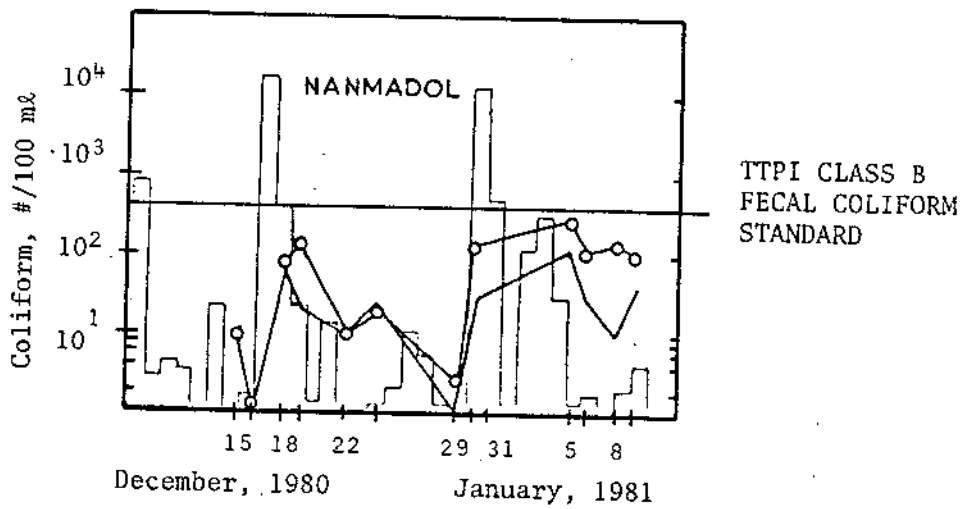

Figure 12b. Marine fecal and total coliform at Nanmadol (Kolonia).

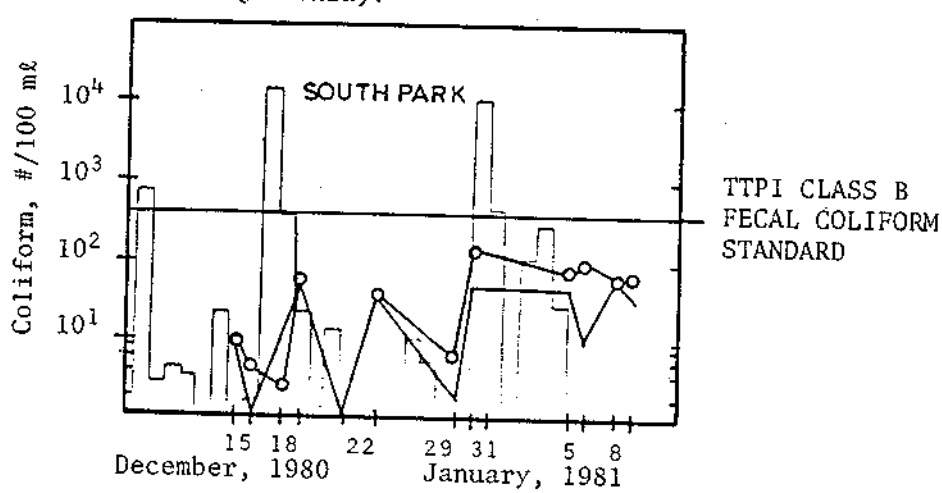

Figure 12c. Marine fecal and total coliform at South Park (Kolonia).

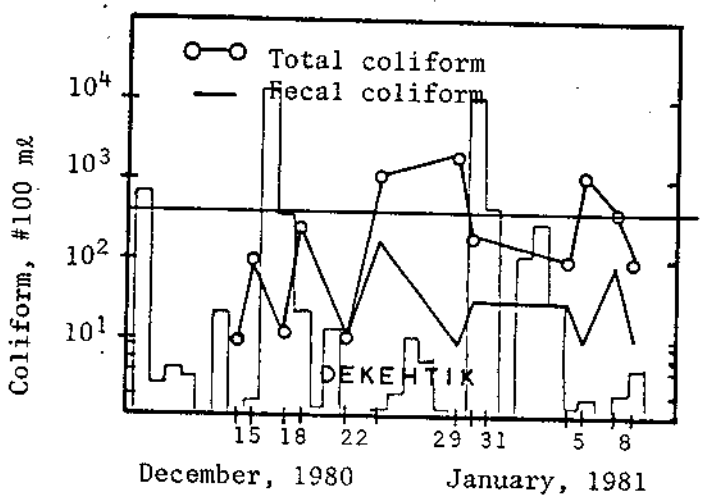

Figure 13a. Marine fecal and total coliform at Dekehtik (Kolonia).

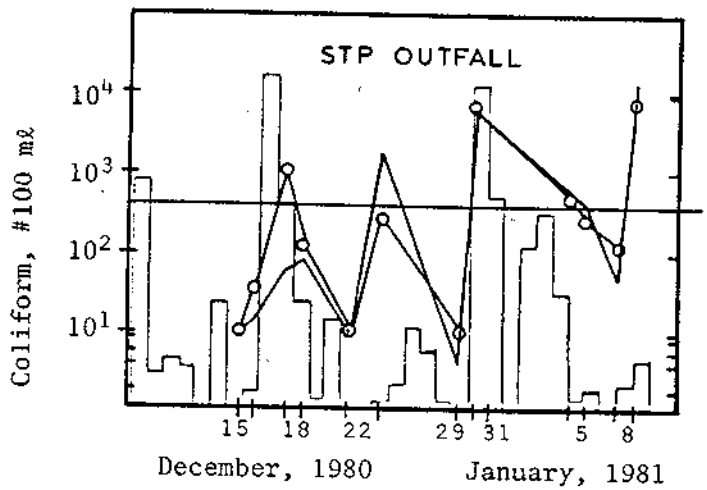

Figure 13b. Marine fecal and total coliform at STP Outfall (Kolonia).

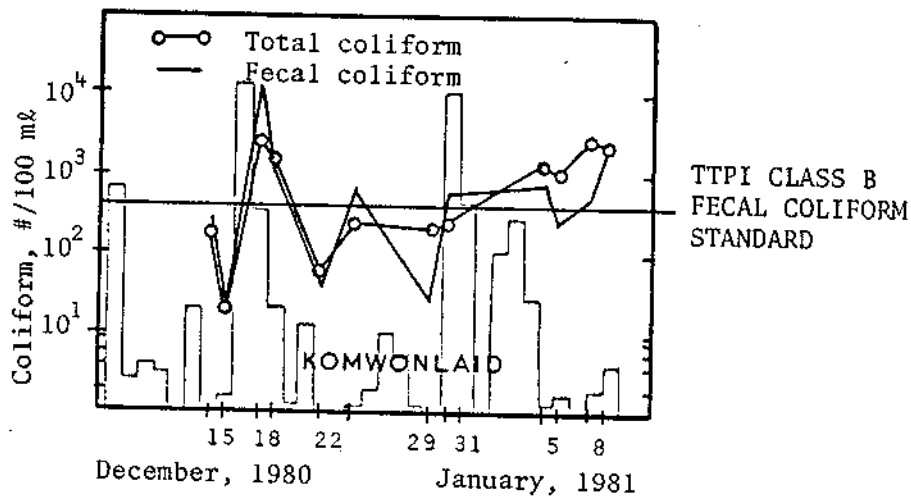

Figure 14a. Marine fecal and total coliform at Komwonlaid (Kolonia).

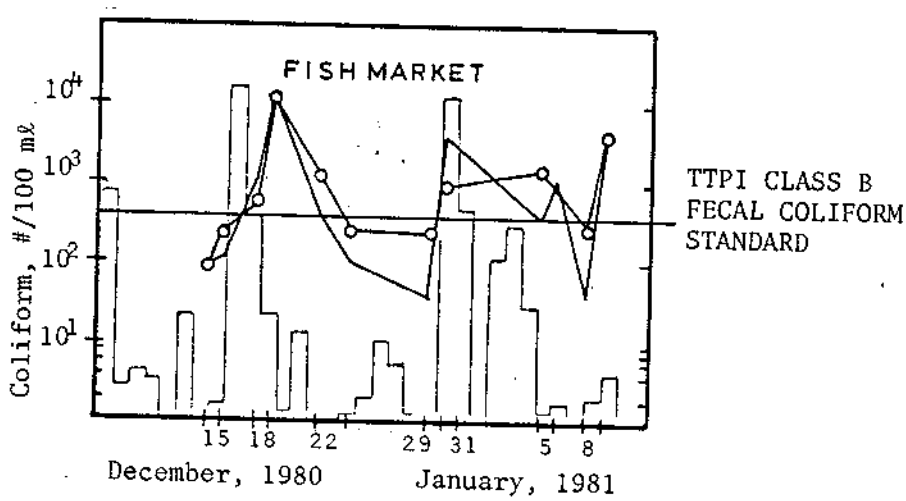

Figure 14b. Marine fecal and total coliform at Fish Market (Kolonia).

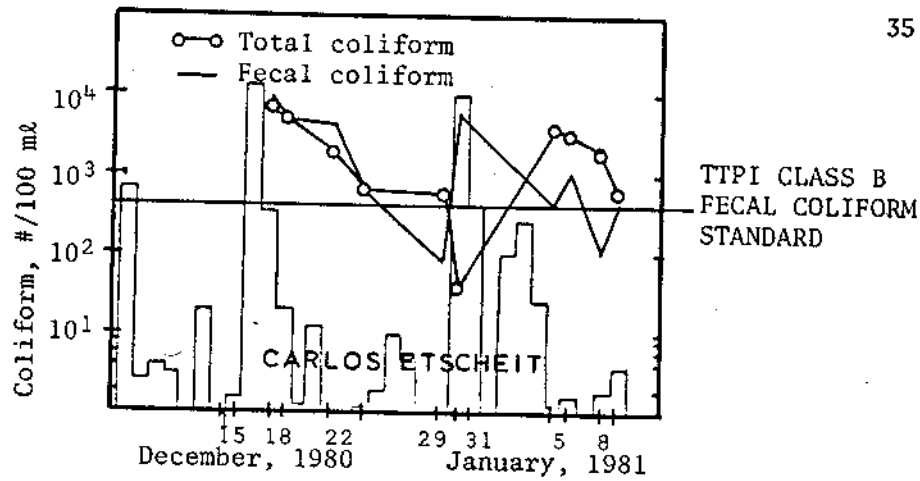

Figure 15a. Marine fecal and total coliform at Carlos Etscheit (Kolonia).

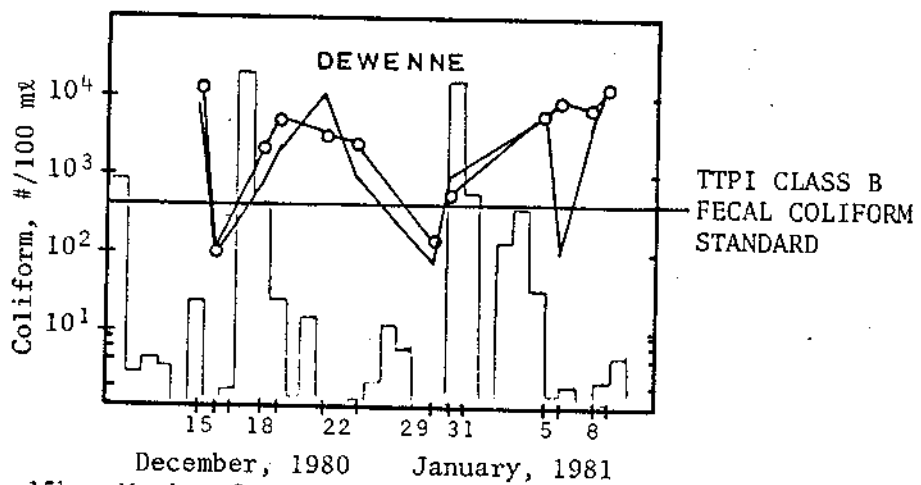

Figure 15b. Marine fecal and total coliform at Dewenne Stream (Kolonia).

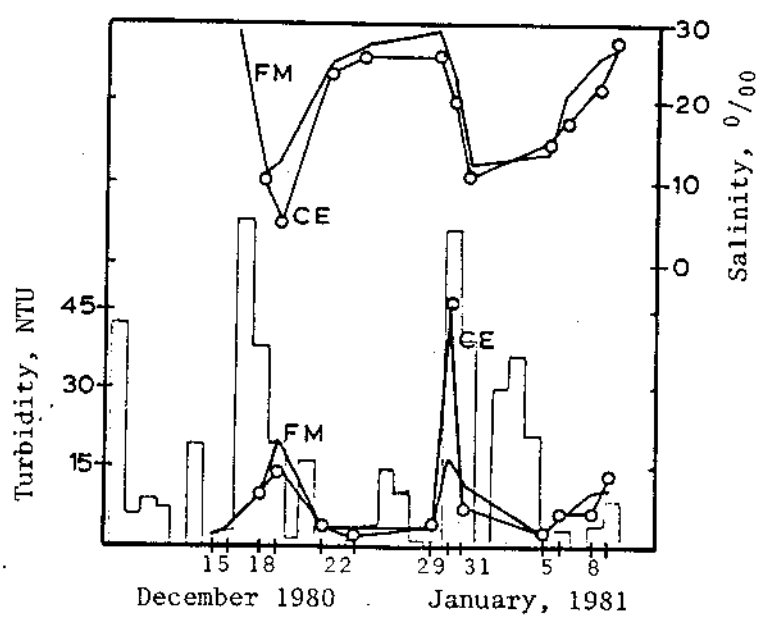

Figure 16. Marine turbidity and salinity at Fish Market and Carlos Etscheit (Kolonia).

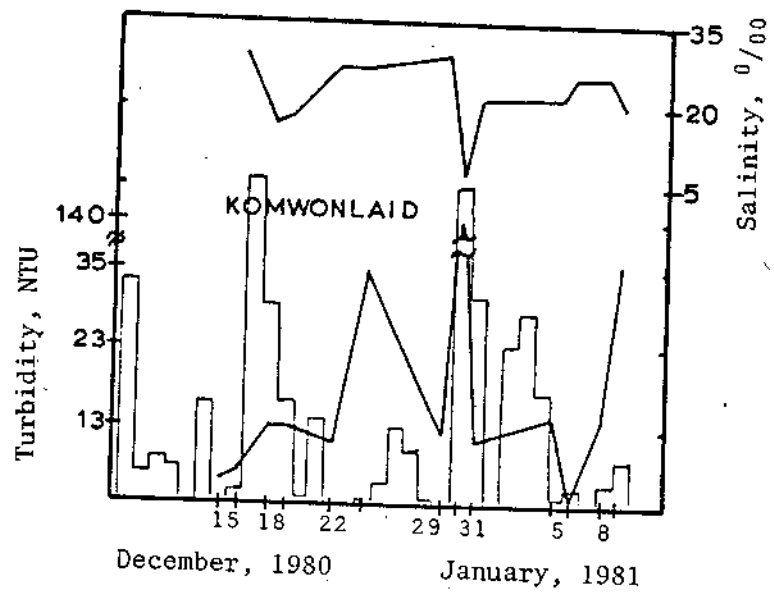

Figure 17a. Marine turbidity and salinity at Komwonlaid (Kolonia).

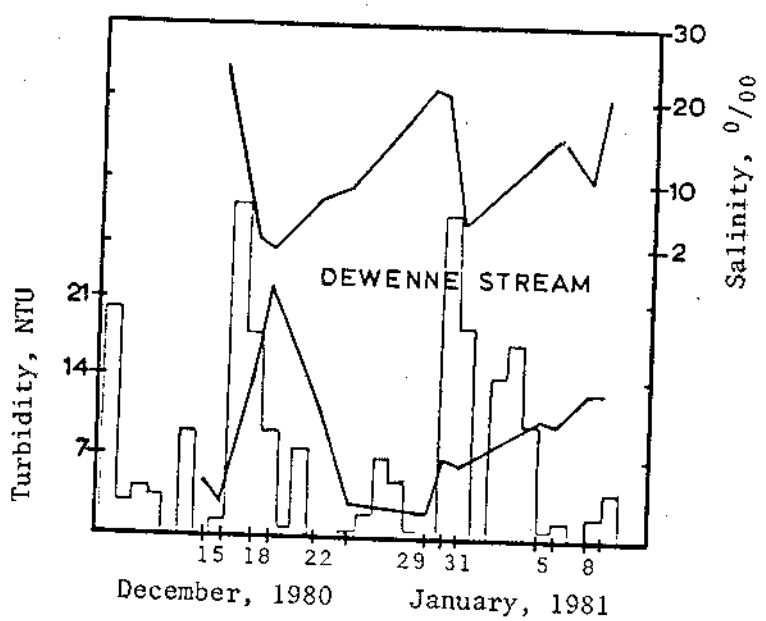

Figure 17b. Marine turbidity and salinity at Dewenne Stream (Kolonia).

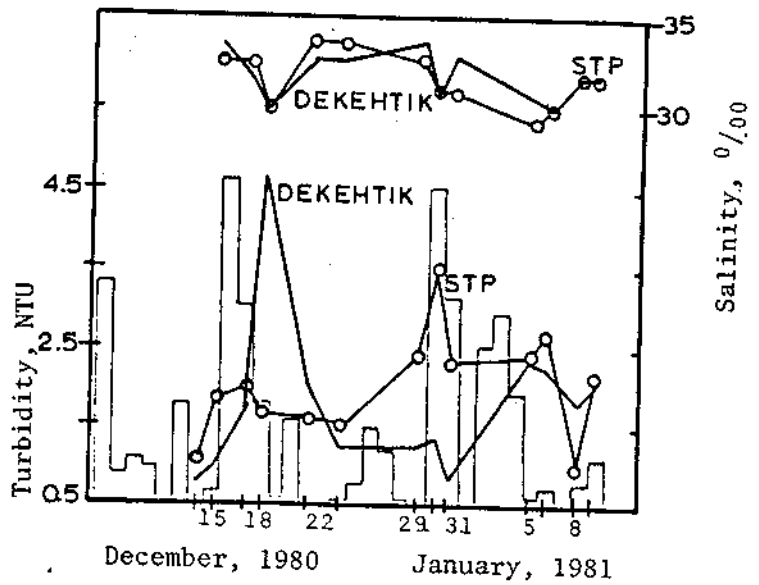

Figure 18. Marine turbidity and salinity at Dekehtik, STP Outfall (Kolonia).

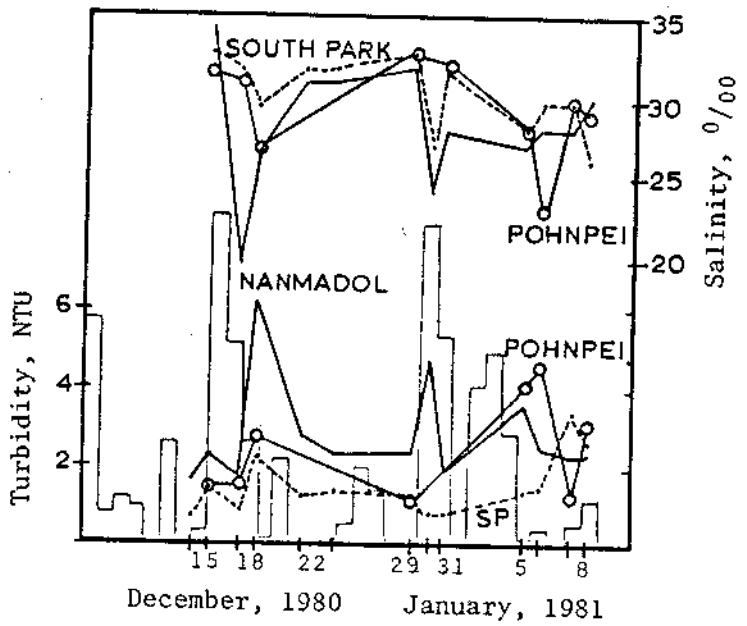

Figure 19. Marine turbidity and salinity at Nanmadol, Pohnpei, South Park Hotels (Kolonia).

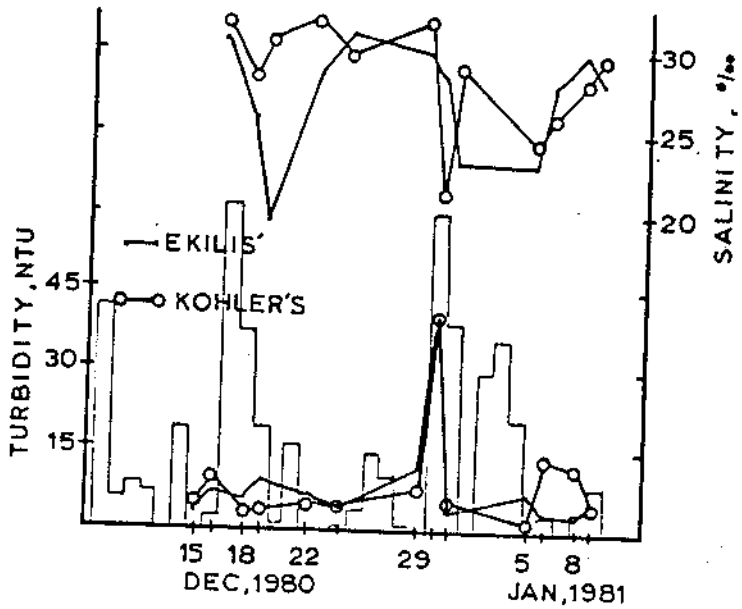

Figure 20. Marine turbidity and salinity at Ekilis, Kohler's Hotels (Kolonia).

1. Freshwater distribution system and sampling sites.

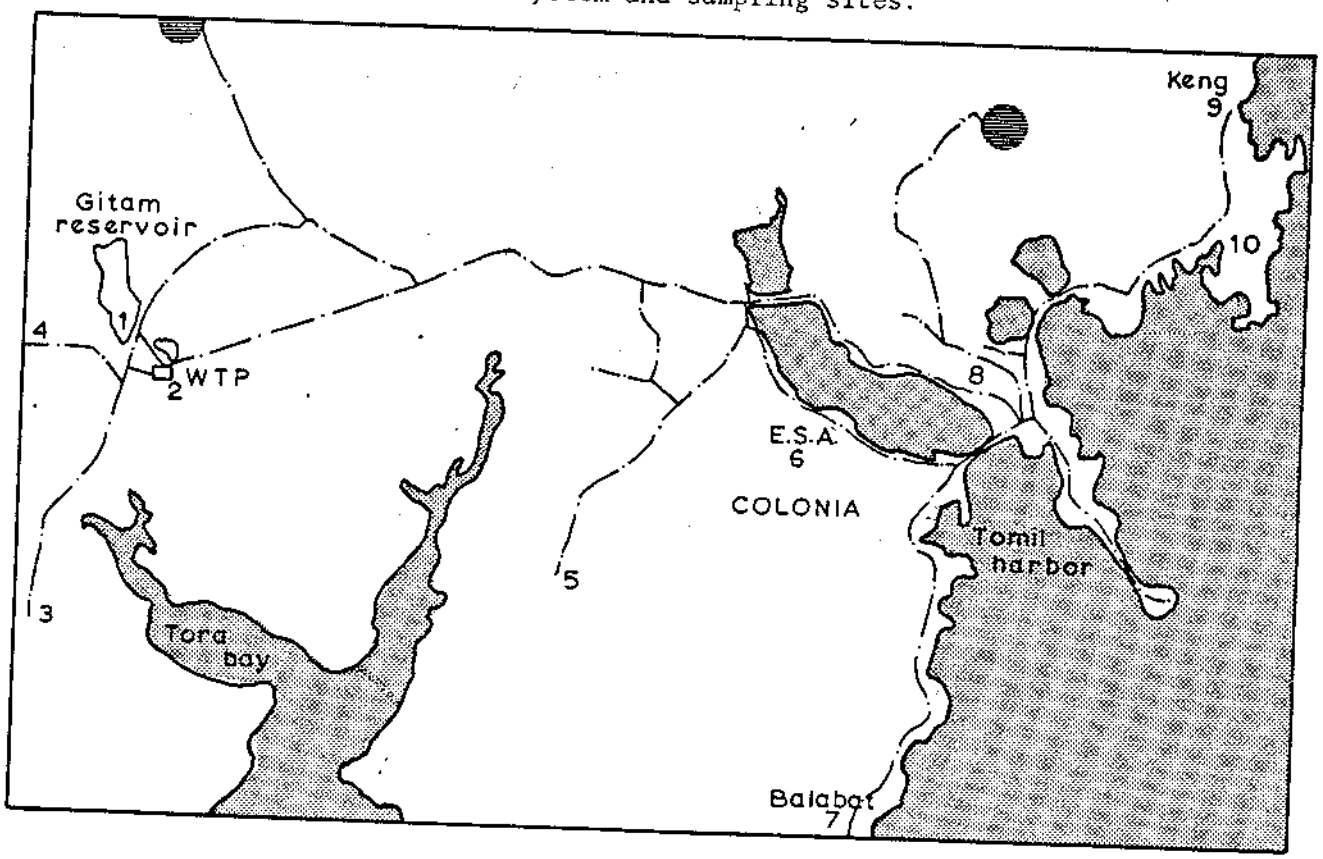

Figure 21. Water distribution system, Colonia (Yap) municipal public water system.

Table 1. Marine water quality data for the district center of Koror (Palau); data summarized from Cowan and Clayshulte (1980).

Parameter	Units	Geometric Mean	Geometric Standard Deviation	Number of Datum	Arithmetic Mean ±	Arithmetic Standard Deviation	Range of Values
Fecal Coliform	#/100 mℓ	1.5	2.86	12	3.4 ±	10.3	Ø - 36
Total Coliform	#/100 mℓ	4.5	4.15	12	12 ±	20.1	Ø - 72
Turbidity	NTU	0.73	1.51	18	0.81 ±	0.44	0.4-2.4
Temperature	°C	29.6	1.02	17	29.6 ±	0.61	29.0-31.5
Salinity	$^{0}/_{00}$	32.5	1.02	18	32.5 ±	0.71	31-34
Dissolved Oxygen	mg/ℓ	6.0	1.15	18	6.1 ±	0.86	4.8- 8.1
	% Saturation	96.4	1.15	18	97.3 ±	14.2	76-133
pH		8.0	1.02	18	8.0 ±	0.13	7.8-8.2

Table 2. Trust Territory of the Pacific Islands (TTPI) classification of coastal waters.

Class AA Waters

The uses to be protected in this class of waters are oceanographic research, the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, compatible recreation, and aesthetic enjoyment.

It is the objective of this class of waters that they remain in as nearly their natural, pristine state as possible with an absolute minimum of pollution from any source. To the extent possible, the wilderness character of such areas shall be protected. No zones of mixing will be permitted in these waters.

The classification of any water area as Class AA shall not preclude other uses of such waters compatible with these objectives and in conformance with the standards applicable to them.

Class A Waters

The uses to be protected in this class of waters are recreational (including fishing, swimming, bathing, and other water-contact sports), aesthetic enjoyment, and the support and propagation of aquatic life.

It is the objective for this class of waters that their use for recreational purposes and aesthetic enjoyment not be limited in any way. Such waters shall be kept clean of any trash, solid materials or oils, and shall not act as receiving waters for any effluent which has not received the best degree of treatment or control practicable under existing technology and compatible with the standards established for this class.

Class B Waters

The uses to be protected in this class of waters are small boat harbors, commerical and industrial shipping, bait fishing, compatible recreation, the support and propagation of aquatic life, and aesthetic enjoyment.

It is the objective for this class of waters that discharges of any pollutant be controlled to the maximum degree possible and that sewage and industrial effluents receive the best degree of treatment control practicable under existing technology and compatible with the standards established for this class.

The Class B designation shall apply only to a limited area next to boat docking facilities in bays and harbors. The rest of the water area in such bay or harbor shall be Class A.

Table 3. Trust Territory of the Pacific Islands (TTPI) marine water quality standards.

Parameter	Units	Class AA	Class A	Class B
Total Coliform	#/100 mℓ	<230		
Fecal Coliform	#/100 mℓ		<400	<400
pH	*	← 8.10 ± 0.40 →		
Total Nitrogen (TN)	mg/ℓ	* ≤0.40	≤0.40	≤0.80
Total Phosphorus (TP)	mg/ℓ	* ≤0.025	≤0.025	≤0.050
TN/TP (mass ratio)	---	* 9≤18≤27	9≤18≤27	6≤12≤18
Dissolved Oxygen (DO)	mg/ℓ	≥6.0 or 75% of saturation, whichever is greater	≥5.0	≥4.5
Salinity	0/00	* ← 32±3 →		
Temperature	°C	* ← 29±1.5 →		
Turbidity	NTU	* ≤1.0	≤1.0	≤2.0

* Proposed marine water quality standards from Cowan and Clayshulte (1980). These proposed amendments apply to TTPI marine waters in general. If isolated areas in the Territory have water quality parameter values in violation of these proposed standards, sufficient data should then be gathered in order to establish the normal conditions for those special cases.

Table 4. Water quality data: Koror, Palau (marine).
Data from the local Environmental Sanitation Laboratory.

SITE No.	DESCRIPTION (month/day)	FECAL COLIFORM, #/100 ml														TURBIDITY NTU		
		1978				1979				1980					1981	1980		
		7/12	7/19	8/23	9/28	1/18	2/14	8/14	8/17	2/4	2/5	10/21	11/19	12/9	2/18	10/21	11/19	12/9
1	T-Dock, east side									61		23	48	<10	660	1.2	1.2	2.3
-	T-Dock, swimming pool				20			5	0		0							
-	T-Dock, north side	TNTC	193	TNTC					6		8							
-	Renrak Bridge									0								
-	Airai					3												
-	Blue Lagoon Hotel					53												
2	MOC									6		1	18	0	10	1.8	1.1	1.5
3	Palau High School											0	-	0	28	2.3	-	3.0
-	East of Arakabesan Is.									0								
4	DNT Hotel			TNTC		TNTC		186				40	60	190	640	1.6	1.8	3.2
5	Kyosha Anderson Dock			TNTC		TNTC		192				31	130	520	97	2.0	2.4	3.1
6	Metal Bai	98	40	245				103			82	9	-	6	32	2.1	-	1.4
-	Meyuns									126								
-	Cave Inn	26	6				9	3			3							
-	Peleliu Club			112				85			98							
-	North of Ngarol Is.									0								
-	Ngardis									0								
7	M-Dock	18	4				27				28	10	-	3	1	0.8	-	1.1
8	Community Club	148	80	123		215		215			198	920	452	150	280	1.2	1.2	5.2
-	Caroline Fishery	18	5								21							
9	Micronesian Indust. Corp.							9				0	-	0	-	0.6	-	0.6
10	Malakal Fishery	22	8				14	18	12	12	18	1	9	1	7	0.4	0.8	0.5
11	Van Camp						8		TNTC			207	26	<10	41	0.7	0.8	0.6
-	Malakal Harbor				9													
-	South Tip Malakal				8													
-	Mariculture				112						120							
12	STP Outfall				6					0		0	4	0	6	0.3	0.6	0.4
13	STP Shore	5	3									0	0	0	1	0.5	0.6	0.4
-	North of Malakal	3	0															
14	Iwayama Bay									56		-	-	-	121	-	-	-
-	Iwayama Bay									0								
15	Iwayama Bay									3		-	-	-	24	-	-	-
-	Iwayama Bay									0								
-	North of Arakabesan OICC Outfall						12			0					320			

Table 4. continued.

SITE No.	DESCRIPTION	TURBIDITY NTU	pH				WATER TEMPERATURE, °C				DISSOLVED OXYGEN, mg/ℓ			
	(month/day)	1981	1980			1981	1980			1981	1980			1981
		2/18	10/21	11/19	12/9	2/18	10/21	11/19	12/9	2/18	10/21	11/19	12/9	2/18
1	T-Dock, east side	1.3	7.5	7.8	8.3	7.3	28	28	31	30	6.0	6.1		
-	T-Dock, swimming pool													
-	T-Dock, north side													
-	Renrak Bridge													
-	Airai													
-	Blue Lagoon Hotel													
2	MOC	2.0	8.7	8.2	8.4	7.7	28	28	31.5	29.5	6.3	6.5		
3	Palau High School	2.7	9.0	-	8.4	7.5	29	-	33.5	29	8.8	-		
-	East of Arakabesan Is.													
4	DNT Hotel	2.5	8.9	8.5	8.3	7.7	28	28	32.5	30.5	6.5	7.8		
5	Kyosha Anderson Dock	2.0	9.0	8.8	8.2	7.6	28	29	30.5	29.5	8.6	8.3		
6	Metal Bai	2.5	9.0	-	8.2	7.6	29	-	32	30	8.0	-		
-	Meyuns													
-	Cave Inn													
-	Peleliu Club													
-	North of Ngarol Is.													
-	Ngardis													
7	M-Dock	1.6	8.8	-	8.0	7.7	28	-	29	31	6.0	-		
8	Community Club	2.3	8.7	8.9	8.1	7.6	28	27	31.5	30	6.1	6.8		
-	Caroline Fishery													
9	Micronesian Indust. Corp.	-	8.9	-	8.0	-	28	-	30	-	6.9	-		
10	Malakal Fishery	1.5	8.8	8.8	8.2	7.7	28	28	29.5	30	6.7	6.4		
11	Van Camp	0.6	8.9	8.9	8.2	7.7	28	28	29.5	29.5	5.7	6.0		
-	Malakal Harbor													
-	South Tip Malakal													
-	Mariculture													
12	STP Outfall	1.4	8.9	8.9	8.3	7.7	28	28	29.5	30	6.3	6.2		
13	STP Shore	0.7	9.0	9.0	8.2	7.6	28	28	29.5	30	6.3	6.2		
-	North of Malakal													
14	Iwayama Bay	2.2	-	-	-	7.4	-	-	-	30	-	-		
-	Iwayama Bay													
15	Iwayama Bay	0.6	-	-	-	7.6	-	-	-	31.5	-	-		
-	Iwayama Bay													
-	North of Arakabesan													
	OICC Outfall	2.4				7.6				30				

Table 5. Marine water quality data for Ponape; data summarized from Cowan and Clayshulte (1980).

Site 6 Mwalok; Site 7 Kolonia (Class B);
Site 3, 5 and 10: Likie, Dekehtik and Nanuh (Class B);
Sites 1-5 and 8-14 (Classes AA, A, B); see Cowan and Clayshulte (1980).

SITE(s)	PARAMETER	UNITS	GEOMETRIC Mean	GEOMETRIC Standard Deviation	NUMBER of Datum	ARITHMETIC Mean ± Standard Deviation	RANGE of Values
6	Fecal Coliform	#/100 mℓ	244	1.86	3	--	120-380
7			2137	2.81	3	--	760-6000
3,5,10			6.6	5.60	9	--	Ø-130
1-5,8-14			3.7	5.10	36	--	Ø-156
6	Total Coliform	#/100 mℓ	208	5.36	3	--	30-580
7			2479	4.16	3	--	780-12200
3,5,10			15	4.72	9	--	Ø-135
1-5,8-14			8.1	4.72	36	--	Ø-135
6	Turbidity	NTU	2.1	2.03	3	2.5 ± 1.78	1.1-4.5
7			4.6	2.49	3	6.1 ± 5.95	2.5-13
3,5,10			1.1	2.07	9	1.4 ± 1.10	0.4-3.6
1-5,8-14			1.0	1.87	36	1.3 ± 0.87	0.4-3.6
6	Temperature	°C	28.7	1.01	3	28.7 ± 0.4	28.2-28.9
7			27.1	1.04	3	27.1 ± 1.1	25.9-28.0
3,5,10			29.2	1.04	9	29.2 ± 1.1	27.8-31.2
1-5,8-14			29.3	1.03	36	29.3 ± 0.8	27.8-31.2
6	Salinity	0/00	19.1	2.12	3	22.3 ±12.4	8-30
7			7.5	3.14	3	10.3 ± 7.2	2-15
3,5,10			29.5	1.11	9	29.7 ± 2.9	24-32
1-5,8-14			29.6	1.09	36	29.7 ± 2.6	24-34
6	Dissolved Oxygen	mg/ℓ	6.0	1.06	3	6.0 ± 0.36	5.7-6.4
7			7.0	1.04	3	7.0 ± 0.25	6.8-7.3
3,5,10			7.1	1.12	9	7.2 ± 0.86	6.3-8.8
1-5,8-14			7.9	1.21	36	8.0 ± 1.59	4.8-12.7
6		% Saturation	89.2	1.13	3	89.7 ±11.1	78-100
7			95.3	1.01	3	95.3 ± 0.6	95-96
3,5,10			111.	1.15	9	112 ±16.0	96-143
1-5,8-14			123.	1.22	36	125 ±26.2	75-205
6	pH		8.0	1.01	3	8.0 ± 0.06	8.0-8.1
7			8.2	1.01	3	8.2 ± 0.10	8.1-8.3
3,5,10			8.1	1.02	9	8.1 ± 0.14	7.8-8.2
1-5,8-14			8.1	1.02	36	8.1 ± 0.16	7.8-8.5

Table 6. Coliform densities (marine): Kolonia, Ponape. Data from the local Environmental Sanitation Laboratory.

Total Coliform, #/100 mℓ

SITE	1977 OCT	1977 NOV	1978 FEB	1978 MAR	1979 OCT	1979 DECEMBER		1980 JAN	1980 FEB	1980 MAY	1980 JUNE	1980 AUG	1980 SEPT	1980 NOVEMBER	
1. Sohehs Powe School	350	1150	2630	10								100			
2. Ekilis Hotel	TNTC*		TNTC	TNTC						TNTC		TNTC			
3. Kohler's Hotel	170		TNTC	205					TNTC			330	200		
4. Nanmadol Hotel	1590		65	70											
5. South Park Hotel															
6. Lidakika		TNTC	570	65	65	1060	750	1100	TNTC	1030	30	TNTC	720	10	0
7. Club Kolonia			TNTC			950	TNTC	1180		1810	Confluent				
8. Fish Market			TNTC			TNTC	TNTC	TNTC		TNTC	Confluent	260		TNTC	
9. Carlos Etscheit			6380	TNTC		TNTC	TNTC	TNTC						260	
10. Kahmar River			188	TNTC					165						
11. Nanpil River															
12. Tekehtik Dock									TNTC	550	20	TNTC		0	40
13. Komwonlaid					290				240	TNTC				600	530
14. STP Outfall															
15. Nett Point Nett side											Confluent				
Kolonia side											370				

Fecal Coliform, #/100 mℓ

1. Sohehs Powe School	110	105	1610	0								80			
2. Ekilis Hotel	TNTC		TNTC	6205						TNTC		TNTC			
3. Kohler's Hotel	15		TNTC	145					TNTC			60	170		
4. Nanmadol Hotel	1390		0	5											
5. South Park Hotel															
6. Lidakika		TNTC	725	10	0	960	720	700	TNTC	810	80	750	580	20	0
7. Club Kolonia			4375			880	TNTC	890		1530	TNTC				
8. Fish Market			TNTC			TNTC	TNTC	TNTC		TNTC	TNTC	460		TNTC	
9. Carlos Etscheit			515	788		TNTC	TNTC	TNTC						400	
10. Kahmar River			148	TNTC					97						
11. Nanpil River															
12. Tekehtik Dock									TNTC	340	10	290		0	20
13. Komwonlaid					250				368	TNTC				300	470
14. STP Outfall															
15. Nett Point Nett side											30				
Kolonia side											280				

*TNTC - Too numerous to count

Table 7. Public water system turbidity, pH and water temperature: Koror, Palau. Data from the local Environmental Sanitation Laboratory.

Turbidity, NTU

SITE	1978	1979			1980									1981					
	OCT	JAN	FEB	AUG	JAN		AUG	SEPTEMBER				OCT	NOV	DEC	JAN		FEB	MAR	MAY	
							1	18	22	26	29	1	14	30	20	21		11	20	28
1. WTP Influent							6.0						15	10	10	8.0	9.0			11
2. WTP Effluent		1.0					3.4						8.4	10	7.7	6.5	6.0			6.0
3. Watermaster's House													9.7			6.5	7.5			
4. Continental Hotel																				
a. Restroom							4.0	3.9	10	10	9.0		8.4	5.1	10	7.5	24			
b. Kitchen							4.1	3.6	10	10	10	12[a]								
c. Tank #2									12		10	12[b]								
5. Harris Elem School					3.5	3.0	3.2									7.0	5.0			10
6. PMCA: T-Dock	6.0		1	.14	5.0	3.5	3.2						9.7	8.5	8.2	7.0	7.6	3.1	57	14
7. New Koror Hotel													8.3	7.5	8.9	7.0	7.0			
8. Central Market	5.0			.13	5.6	2.8	3.4						8.5	7.0	8.6	7.0	8.5		52	9.5
9. Environmental Lab							3.4		14				8.8		9.4	7.0	7.9			
10. PW Garage: M-Dock							4.9						17	7.3		7.0	8.5	2.9	55	11
11. Burger Hut							3.0													
12. Meyums (Last House)	7.5			.15			4.2						8.0	6.8		7.0	8.2		58	13
13. Malakal Fisheries				.13			4.8						7.8	6.5	9.5	7.6	8.0		14	14
14. Tuker					5.6													5.0		
15. Tiul (Last House)		1			4.6		4.3							7.2	8.9	7.5	8.7			12
Peleliu Club	5.0																			
Ngermid (private)																				
Ngermid (public)			1																	
Mokko				.14																
Maris Stella School																				
WTP (After Filter)		.04																		
Monthly Arithmetic Means*	5.9			.14	4.2		3.8						9.6	7.6	8.7	7.0	7.5	3.7	47	11
Number of Datum	4			5	8		10						9	8	7	11	11	3	5	8

*(Sites 2,3, 5-15, Peleliu Club, Mokko & Maris)

Table 7. Con't.

SITE	pH															Water Temperature, °C					
	1980							1981								1980					
	AUG	SEPTEMBER				OCT	NOV	DEC	JAN		FEB	MAR	MAY		AUG	SEPTEMBER			OCT	NOV
	1	18	22	26	29	1	14	30	20	21		11	20	28		22	26	29	1	14
1. WTP Influent	7.9						7.9	6.8	7.2	6.5	7.2			6.9	28					29
2. WTP Effluent	7.6						7.8	7.1	7.2	6.8	7.2			7.0	28					29
3. Watermaster's House							7.6			6.9	7.2									28
4. Continental Hotel																				
a. Restroom	7.8	7.5	7.5	7.2	7.5		7.7	7.6	7.2	6.2	7.4				28	27	26	27		29
b. Kitchen	7.8	7.5	7.5	7.2/	7.2	7.8[c]									28	27	26/	26	27	
c. Tank #2			7.4	7.4	7.4	7.6[d]										27	24	26	27	
5. Harris Elem School	8.0									6.2	7.2			6.9	28					
6. PMCA: T-Dock	7.7						7.6	7.0	7.2	7.0	7.2	7.1	6.8	7.2	29					28
7. New Koror Hotel							7.8	6.8	7.2	6.8	7.2									27
8. Central Market	7.8						8.7	7.4	7.4	6.8	7.6		7.0	7.0	28	27				28
9. Environmental Lab	7.9		7.6				8.0		7.6	6.6	7.6				28					28
10. PW Garage: M-Dock	7.7						8.1	7.0		6.9	7.2	7.2	6.9	7.0	28					28
11. Burger Hut	7.8														28					
12. Meyuns (Last House)	8.5						8.9			6.9	7.5		7.3	7.2	28					28
13. Malakal Fisheries	8.8						8.8		7.5	6.8	7.5		7.2	7.3	27					28
14. Tuker												7.0								
15. Tiul (Last House)	7.8								7.4	6.4	7.5			7.3	27					

a. Oct 1, 1980: Four samples, all values 12
b. Oct 1, 1980: Two samples, both values 12
c. Oct 1, 1980: Sample values 7.8, 7.7, 7.8, 7.7
d. Oct 1, 1980: Sample values 7.5, 7.8

Table 8. Public water system coliform and residual chlorine: Koror, Palau. Data from the local Environmental Sanitation Laboratory.

Total Coliform, #/100 ml

SITE	1978	1979				1980										1981					
	OCT	JAN	FEB	MAR	AUG	JAN	FEB	MAR	AUG	SEPTEMBER				OCT	NOV	DEC	JAN		FEB	MAR	MAY	
									1	18	22	26	29	1	14	30	20	21		11	20	28
1. WTP Influent																						
2. WTP Effluent		0	-	0					0						0	TNTC	7**	0	0			20**
3. Watermaster's House									0						0	2	0	0	0			0
4. Continental Hotel															0			0	0			
a. Restroom							0		0	3	0	0	0		0	15	0	0	0			
b. Kitchen									0	0	26	7/0	0	0[a]								
c. Tank #2											0		0	0[b]								
5. Harris Elementary School	3					0/7	0	0	0									0	0			0
6. PMCA: T-Dock	132	0	11/0	0	0	0/0/8	0	0	0						0	13	25**	0	0	0	3	0
7. New Koror Hotel															0	3	6**	0	0			
8. Central Market	0			0	0	0/0/0	0	0	0						0	4	3**	0	0		6	0
9. Environmental Laboratory									0		0				0		7**	0	0			
10. PW Garage: M-Dock						0	0	0	0						0	33		0	0	0	0	0
11. Burger Hut								0														
12. Meyuns (Last House)	TNTC*	100		0	0				0						0	27		0	0		0	0
13. Malakal Fisheries					TNTC				0						0	**	26**	0	0		0	0
14. Toker		0		0	0	0/37	0	0												0		
15. Tiul (Last House)		0/0		0		0	0	0	0							28	2**	0	0			0
Peleliu Club	---	0	0	0																		
Ngermid (private)		TNTC																				
Ngermid (public)			54/2		Conf																	
Mokko			E	0	0																	
Maris Stella School							0	0														
WTP (After Filter)		82		TNTC																		
Monthly Geometric Means (Sites 2,3, 5-15, Peleliu Club, Mokko & Maris)	13	3.1	2.2	0	2.1	1.9	0	0	0						0	13	5.6	0	0	0	1.8	0
Number of Datum	4	8	3	8	5	12	7	7	10		1				9	6	7	11	11	3	5	7

Table 8. Con't.

Free Residual Chlorine, mg/ℓ

	1978	1979				1980										1981					
	OCT	JAN	FEB	MAR	AUG	JAN	FEB	MAR	AUG	SEPTEMBER				OCT	NOV	DEC	JAN		FEB	MAR	MAY	
									1	18	22	26	29	1	14	30	20	21		11	20	28
1. WTP Influent									0						0	0	0	0	0			0
2. WTP Effluent		2.4	0	3.5					5.8						3.0	0	2.5	2.8	4.3			0.2
3. Watermaster's House															2.0			2.5	4.0			
4. Continental Hotel																						
a. Restroom							0		3.0	2.9	1.5	0.1	0.3		2.0	0	2.0	2.6	2.5			
b. Kitchen									4.0	3.4	1.5	.1/.1	0.4	0.9[c]								
c. Tank #2											0.4		0.5	0.3[d]								
5. Harris Elementary School	0					0.2/0	0.2	0.4	2.8									1.0	2.0			0.1
6. PMCA: T-Dock	0	1.1	0/.3	1.0	2.0	0/.4/0	0.2	0.2	2.8						0.3	0	0	0.5	2.0	0	0.5	0.1
7. New Koror Hotel					-										0.5	0	0	1.4	1.0			
8. Central Market	1.0			0.8	2	0/.4/0	0.1	0.2	2.7						0.5	0	0	1.5	0.8		0.5	0
9. Environmental Laboratory									2.7		0.2				0.5		0	1.3	0.8			
10. PW Garage: M-Dock						0.8	0.3	0.2	2.5						0.3	0		0	1.5	0.5	0.7	0
11. Burger Hut									2.0													
12. Meyuns (Last House)	0	0		0.2	-2.0				0						0.8	0		0	0.8		0.1	0.1
13. Malakal Fisheries					0				1.1						0.2	0	0	0.4	0.6		0	0
14. Tuker		2.3		1.8	2.0	0/0	0.1	0.1												0		
15. Tiul (Last House)		0/1.0		0.2		0.4	0.2	0.1	2.0							0	0	0.5	0.5			0.1
Peleliu Club	0	1.4	0.3	0.3																		
Ngermid (private)																						
Ngermid (public)			0/0		0																	
Mokko				0.3	2.0																	
Maris Stella School																						
WTP (After Filter)		0		0																		

* TNTC = Too numerous to count: Total coliform (>80/100 mℓ).
** TNTC non coliform
a. Oct 1, 1980: Four samples, all values 0
b. Oct 1, 1980: Two samples, both values 0
c. Oct 1, 1980: Four samples, all values 0.9
c. Oct 1, 1980: Two samples, both values 0.3

Table 9. Public water system: Kolonia, Ponape. Data from the local Environmental Sanitation Laboratory.

Total Coliform, #/100 mℓ

S I T E	1977 OCT	1977 NOV	1978 FEB	1978 MAR	1978 DEC	1979 JAN	1979 FEB	1979 OCT	1979 NOV	1979 DEC	1980 JAN	1980 FEBRUARY	1980 MAR	1980 APR	1980 MAY	1980 JUNE	1980 AUG	1980 SEPT	1980 NOV
1A Water Plant Influent	337	TNTC*	656	345	158							74	83	128		92	62	TNTC	
1B Water Plant Effluent							0					0	0	0		0	0	0/0	
2 Namiki Restaurant							0	0		0/0/0/0		0/0/0		0	0	0	0/0	0/0/0/0	0/0
3 Sokehs Bridge										0		0			0/13	0	0/0	0	0
4 Ngatik																	0		
5 Danipei						0									2	0	0		
6 Dekehtik						0	0	0				0		0	0	0	0		0
7 Federation						0								0	0	0	0		1
8 Sanitation Laboratory		3/256	0	0	48	0	0	0/0/0	17	386	66	0/15/2/8/13	0/0		0[a]	0	0/0	0	
9 Komwonlaid						0	0	0		0				0	0	0	0	0/24	0
10 South Park Hotel										0/0					0	0	0	0/0	
11 Martin's Store								0		106	33	0			0			0	
Monthly Geometric Means (sites 1B - 11)		28				0.0	0.0	0.0		2.9	47	2.0	0.0	0.0	1.2	0.0	0.0	1.3	0.0
Number of Datum		2	1	1	1	5	5	7	1	10	2	12	3	5	17	9	13	13	6

Fecal Coliform, #/100 mℓ

1A Water Plant Influent	152		181	84	29							68	54	117		64	35	245	
1B Water Plant Effluent							0					0	0	0		0	0	0/0	
2 Namiki Restaurant							0	0		0/0/0/0		0/0/0		0	0	0	0/0	0/0/0/0	0/0
3 Sokehs Bridge										0		0			0/8	0	0/0	0	0
4 Ngatik																	0		
5 Danipei						0									9	0	0		
6 Dekehtik						0	0	0				0		0	0	0	0		0
7 Federation						0								0	0	0	0		0
8 Sanitation Laboratory		0/77	0	0	2	0	0	0/0/0	3	252	41	0/9/2/7/8	0/0		0[a]	0	0/0	0	
9 Komwonlaid						0	0	0		0				0	0	0	0	0/0	0
10 South Park Hotel										0/0					0	0	0	0/0	
11 Martin's Store								0		30	27	0			0			0	
Monthly Geometric Means (sites 1B - 11)		8.8				0.0	0.0	0.0		2.4	33	1.8	0.0	0.0	1.3	0.0	0.0	0.0	0.0
Number of Datum		2	1	1	1	5	5	7	1	10	2	12	3	5	17	9	13	13	6

*TNTC = Too numerous to count: Total Coliform (>80/100 mℓ); Fecal Coliform (>60/100 mℓ).
a. May, 1980: Eight coliform analyses, all values zero.

Table 9. Con't.

Free Residual Chlorine, mg/ℓ

SITE	1978 FEB	1979 JAN	FEB	OCT	NOV	DECEMBER	1980 JAN[b]	FEBRUARY	MAR	APR	MAY	JUNE	AUGUST	SEPTEMBER	NOVEMBER
1A Water Plant Influent			2.0					1.8	1.0	2.5		>3	3.0	3.0 3.0	
1B Water Plant Effluent			3.0	2.8		3/1.5/3/0.4		2.5/1.8/2.0		2.0	0	1.7	1.5 2.2	2.5/2.8/2.5/2.5	1.8 1.5
2 Namiki Restaurant						0.5		3.0			1.0 0	3.0	0.2 2.5	0.3	0
3 Sokehs Bridge													0		
4 Nagtik											0	0.2	0.5		
5 Danipei															
6 Dekehtik		0.4	0.2	1.5				0.5		1.0	0	0.7	0.2		0.1
7 Federation		1.5								2.0	0	>3	0.8		0
8 Sanitation Laboratory	0.5	0	0	0/0/0	0	0	0	2.5/0/0/0/0	.2/.2		AVE. 0.4	0.4	0.5 0	0	
9 Komwonlaid		1.0	2.5	2.2		3.0				1.0	0	1.5	0.5	1.0 1.5	1.4
10 South Park Hotel						0.3/0.3					3.0	1.5	0.5	2.7 2.5	
11 Martin's Store				2.2		0	0	2.5			2.0			1.3	

TURBIDITY, NTU

SITE	1978 NOVEMBER	DECEMBER	1979 FEBRUARY	MARCH
1A Water Plant Influent	0.2 0.1	0.1 0.2	0.2 0.1	0.2/0.2/0.2
1B Water Plant Effluent	0.2/0.1/0.1	0.2	0.2 0.1	0.1 0.2
8 Sanitation Laboratory	0.1 0.1	0.1 0.1	0.2	0.3 0.6

b = System not disinfected.

Table 10. Community Water Systems: Ponape.

SITE	DATE mo/day/yr	COMMENTS	Total Coliform #/100 mℓ	Fecal Coliform #/100 mℓ	FC/TC Ratio[a]
Saladak	10/10/79		TNTC[b]	TNTC[c]	~0.8 **
Village Hotel	10/10/79		TNTC	557	~7. **
(Uh)	10/30/79		TNTC	TNTC	~0.8 **
	5/23/80	Tank	Confluent	138	— **
		Kitchen	Confluent	187	— **
		Room	TNTC	370	~5. **
	8/20/80		TNTC	TNTC	~0.8 **
Awak Elem School	10/30/79		80	4	0.05
Kinakap	10/30/79	Source	16	7	0.4 **
	5/26/80	Source	131	8	0.06
Ipwitek	10/30/80	Dispensary	0	0	—
	5/26/80	Dispensary	23	14	0.6 **
Rafaela Phillip	2/14/80		44	36	0.8 **
(Nett)	6/30/80		584	522	0.9 **
Ioanis Rosario	2/14/80		9	4	0.4 **
(Nett)	6/27/80		32	21	0.7 **
Sapwalap	5/26/80		28	7	0.25**
Lewis Amor (Uh)	6/30/80		16	2	0.12
Erpehr Redes (Nett)	8/14/80		57	22	0.4 **
Pehleng Elem. School (Kitti)	8/27/80		0	0	—
Sekere Elem. School (Sokehs)	8/27/80		0	0	—

Table 10. Continued.

SITE	DATE mo/day/yr	COMMENTS	Total Coliform #/100 m	Fecal Coliform #/100 m	FC/TC Ratio[a]
Mand Village	9/24/80	Open Dam	12,5	10,8	1.2 **
(Mandolenim)		Tank	55,29	46,15	0.7 **
		School	56	41	0.7 **
		Homes	29,73	15,36	0.5 **
Mwand Island	9/26/80	Source	TNTC	196	~2. **
(Uh)		Home	TNTC	158	~2. **
Parem Island	9/26/80	Tank	TNTC	TNTC	~0.8 **
(Nett)		Home	TNTC	TNTC	~0.8 **
Takaieu Island	9/26/80	Source	168	78	0.5 **
(Uh)		Home	TNTC	TNTC	~0.8 **
Depehk Island	9/26/80	Source	TNTC	304	~4. **
(Uh)		Tank	Confluent	TNTC	— **
		Home	TNTC	TNTC	~0.8 **
Kepiroi	9/24/80	Tank	0	0	—
(Madolenim)					

a Fecal Coliform/Total Coliform Ratio. If 0.20 or higher, recent fecal contamination has occurred (**).
b TC values of TNTC (100 mℓ aliquot) are >80/100 mℓ;
c FC values of TNTC (100 mℓ aliquot) are >60/100 mℓ;
where TNTC = too numerous to count.

Table 11. Private Water Systems: Ponape

	SITE	DATE mo/day/yr	COMMENTS	Total Coliform #/100 mℓ	Fecal Coliform #/100 mℓ	FC/TC Ratio[a]
	Eden Skilling	1/31/80	Rain Catchment	338	201	0.6 **
	Tridel Elidok	3/ 6/80	Spring water	18	14	0.8 **
	Peter Iriarte	4/16/80	Well	TNTC[b]	96	~1. **
			Spring	TNTC	450	~6. **
	Winter Sahle	5/13/80	Rain Catchment	0	0	—
	Ioses Gallen	5/26/80	Spring	TNTC	TNTC[c]	~0.8 **
	A. Paiden (Sokehs)	6/25/80	Spring	45	9	0.20**
	B. Mihkel (Kolonia)	6/25/80	Spring	169	155	0.9 **
	P. Kihleng (Uh)	6/30/80	Spring	466	504	1.1 **
	S. Kihleng (Uh)	6/30/80	Spring	468	158	0.3 **
Nett:	B. Elwihse	8/14/80	Spring	198	160	0.8 **
			Rain Catchment	8	0	0
	S. Loyola		Spring	213	121	0.6 **
	L. Salons		Spring	84	70	0.8 **
	E. Felix		Spring	163	46	0.3 **
	N. Kostika	8/20/80	Rain Catchment	8	0	0
	K. Iriarte		Small Stream	TNTC	TNTC	~0.8 **
	G. Lighor	8/25/80	Spring	64	29	0.5 **
			Small Stream	TNTC	TNTC	~0.8 **
	H. Gallen		Spring	TNTC	TNTC	~0.8 **
	S. Olter		Spring	142	23	0.16
			Rain Catchment	1	0	0

a Fecal Coliform/Total Coliform Ratio. If 0.20 or higher, recent fecal contamination has occurred (**).

b TC values of TNTC (100 mℓ aliquot) are >80/100 mℓ;

c FC values of TNTC (100 mℓ aliquot) are >60/100 mℓ; where TNTC = too numerous to count.

Table 12. Physical and bacteriological parameters and methods used in laboratory analyses. All standard methods of analyses were performed according to the 14th edition (1975).

PARAMETER	METHOD	REFERENCE
PHYSICAL		
Temperature	20-50°C Mercury Thermometer	Standard Methods
Salinity (Refractometer)	Optical Refractometer, direct reading	--
Turbidity	Nephelometer (NTU)	Standard Methods
pH	pH specific ion meter/combination electrode	Standard Methods
Dissolved Oxygen	Azide modified Winkler-titration	Standard Methods
BACTERIOLOGICAL		
Total and Fecal Coliform Bacteria	Membrane Filtration	Standard Methods

Table 13. Precipitation data for Koror (Palau) and Kolonia (Ponape) for study periods.

Koror, Palau						Kolonia, Ponape					
1980	Date	cm	1980	Date	cm	1980	Date	cm	1980	Date	cm
July	1	0.08	July	16	-	Dec.	9	2.8	Dec.	26	1.0
	2	10.2		17	0.6		10	0.4		27	0.7
	3	2.9		18	1.3		11	0.6		28	0.1
	4	0.3		14	1.5		12	0.5		29	0.02
	5	-		20	0.3		13	Trace		30	4.0
	6	1.2		21	Trace		14	1.3		31	2.6
	7	0.9		22	2.2		15	0	1981	Date	
	8	-		23	0.2		16	0.2		Jan 1	-
	9	-		24	-		17	4.1		2	2.0
	10	0.01		25	0.3		18	2.5		3	2.4
	11	4.5		26	0.3		19	1.3		4	1.4
	12	0.5		27	0.9		20	0.1		5	0.1
	13	-		28	-		21	1.1		6	0.2
	14	0.2		29	1.2		22	0.05		7	Trace
	15	1.4		30	0.7		23	Trace		8	0.3
							24	0.08		9	0.6
							25	0.3			

Study Period	Total Precipitation
Marine: 7-30 July	17.01 cm

Study Period	Total Precipitation
Marine: 15 Dec-9 Jan	25.15 cm

Table 14. Marine fecal coliform densities: Koror, Palau.

SITE No.	DESCRIPTION	TTPI CLASS	FECAL COLIFORM, #/100ml JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	24	30	GEOMETRIC MEAN	STANDARD DEVIATION	(n)
1	PMCA: T-Dock	B	65	0	1	>99	880	660	160	320	120	40	140	<10	1260	73	10.07	(13)
2	MOC	B	36	0	0	11	6	10	10	—	0	--	0	0	0	3	3.90	(11)
3	Palau High School	B	5	0	1	6	--	28	19	—	0	40	--	0	0	4	4.66	(10)
4	DNT Hotel: T-Dock	B	0	44	40	66	160	640	20	40	60	680	450	190	310	84	5.87	(13)
5	KA Dock: T-Dock	B	4	64	24	>60	3	97	83	>171	150	>600	<10	520	300	62	5.53	(13)
6	Metal Bai	A	6	1	8	60	10	32	7	--	1	--	5	1	--	6	4.14	(10)
7	M-Dock	B	15	2	1	32	1	1	0	—	24	6	6	3	65	4	4.35	(12)
8	Community Club	B	29	>111	73	>120	740	280	--	970	<10	510	60	150	630	153	4.06	(12)
9	MIC: Malakal	B	12	0	0	11	3	-	4	0	--	>96	—	0	17	4	4.81	(10)
10	Fisheries: Malakal	B	2	3	34	5	4	7	3	1	--	3	0	1	7	3	2.77	(12)
11	Van Camp: Malakal	B	17	51	4	9	2	41	<2	<2	0	—	20	<10	8	7	3.60	(12)
12	STP Outfall	B	0	--	0	0	0	—	—	0	0	—	--	0	—	0	1.00	(7)
13	STP Shore: Malakal	B	23	<2	0	4	1	1	--	0	—	1	—	0	46	2	4.22	(10)
14	Weather Station	AA	<1	1	--	—	0	121	—	0	--	35	--	0	0	3	7.10	(8)
15	Continental Hotel	A	4	0	0	—	0	24	—	1	1	—	—	3	6	2	3.10	(9)

Underscored Data Represent Violations of Standard (≥400/100ml)
-----Underscored Data Represent Possible Violations of Standard.

Table 15. Marine total coliform densities: Koror, Palau.

SITE No.	DESCRIPTION	TTPI CLASS	TOTAL COLIFORM, #/100ml JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	24	30	GEOMETRIC MEAN	STANDARD DEVIATION	(n)
1	PMCA: T-Dock	B	50	2	19	<115	880	340	680	380	100	200	160	<10	>1550	118	6.69	(13)
2	MOC	B	42	0	0	21	16	7	1	--	0	--	0	1	1	3	4.53	(11)
3	Palau High School	B	19	1	2	2	--	1	0	--	0	1	--	0	0	2	2.53	(10)
4	DNT Hotel: T-Dock	B	>128	>202	320	>1230	350	800	<10	120	140	>1640	310	190	260	246	3.56	(13)
5	KA Dock: T-Dock	B	8	67	15	26	3	<26	--	0	210	0	<10	940	290	21	8.76	(12)
6	Metal Bai	A	2	1	6	81	13	47	0	--	0	--	1	5	--	4	5.26	(10)
7	M-Dock	B	0	1	2	51	4	0	0	--	15	17	8	6	59	5	4.62	(12)
8	Community Club	B	76	> 132	170	2	262	300	--	>2580	10	320	10	560	250	110	7.39	(12)
9	MIC: Malakal	B	22	12	0	53	25	--	0	0	--	7	--	1	0	4	5.10	(10)
10	Fisheries: Malakal	B	0	9	21	11	27	21	0	5	--	3	0	2	0	4	3.74	(12)
11	Van Camp: Malakal	B	>156	>325	50	<2	24	> 2	--	2	0	--	170	10	1	12	9.12	(11)
12	STP Outfall	B	8	--	0	1	0	--	--	0	0	--	--	0	--	1	2.20	(7)
13	STP Shore: Malakal	B	>230	< 2	0	11	6	0	--	0	--	8	--	0	0	3	5.81	(10)
14	Weather Station	AA	< 2	2	--	--	1	> 16	--	0	--	19	--	0	0	2	3.49	(8)
15	Continental Hotel	A	3	1	0	--	0	> 20	--	0	2	--	--	9	0	2	3.06	(9)

Table 16. Marine turbidity levels: Koror, Palau.

SITE No.	DESCRIPTION	TTPI CLASS	TURBIDITY, NTU* JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	24	30	GEOMETRIC MEAN	STANDARD DEVIATION	(n)
1	PMCA: T-Dock	B	1.4	1.1	0.9	2.3	1.5	1.3	1.3	1.3	1.7	1.4	0.8	2.3	0.6	1.3	1.47	(13)
2	MOC	B	2.5	2.0	1.9	1.6	2.5	2.0	2.1	--	2.1	--	1.2	1.5	0.9	1.8	1.37	(11)
3	Palau High School	B	2.0	5.3	1.7	2.3	--	2.7	4.2	--	3.6	3.5	--	3.0	1.6	2.8	1.48	(11)
4	DNT Hotel: T-Dock	B	2.6	5.1	2.0	2.1	2.0	2.5	5.0	4.7	6.9	3.7	2.9	3.2	1.8	3.1	1.54	(13)
5	KA Dock: T-Dock	B	1.7	2.3	2.5	2.1	2.0	2.0	3.4	3.7	6.7	9.4	2.0	3.1	1.3	2.8	1.74	(13)
6	Metal Bai	A	2.2	2.2	3.0	2.1	4.5	2.5	2.6	--	3.5	--	2.0	1.4	--	2.5	1.38	(10)
7	M-Dock	B	1.6	1.6	0.9	1.3	1.0	1.6	1.0	--	1.4	1.1	0.9	1.1	0.4	1.1	1.47	(12)
8	Community Club	B	2.1	2.3	3.1	1.5	2.1	2.3	--	4.9	1.8	2.3	2.7	5.2	0.6	2.3	1.75	(12)
9	MIC: Malakal	B	1.8	1.5	1.0	1.4	0.6	--	1.0	0.9	--	0.5	--	0.6	0.7	0.9	1.54	(10)
10	Fisheries: Malakal	B	2.0	2.5	3.4	0.7	1.0	0.6	1.4	0.9	--	0.5	1.0	0.5	0.3	1.0	2.06	(12)
11	Van Camp: Malakal	B	1.3	1.5	1.5	1.3	0.6	1.4	0.9	1.2	1.1	--	0.9	0.6	0.3	1.0	1.63	(12)
12	STP Outfall	B	1.1	--	0.5	0.5	0.6	--	--	0.6	0.4	--	--	0.4	--	0.6	1.41	(7)
13	STP Shore: Malakal	B	0.7	0.6	0.4	0.9	0.4	0.7	--	1.1	--	0.6	--	0.4	0.4	0.6	1.45	(10)
14	Weather Station	AA	1.6	2.1	--	--	1.8	2.2	--	2.8	--	1.9	--	1.5	0.6	1.7	1.58	(8)
15	Continental Hotel	A	1.9	1.2	0.7	--	1.2	0.6	--	1.5	1.6	--	--	1.2	0.4	1.0	1.67	(9)
															ALL DATA	1.5	2.00	(162)

*NTU= Nephelometric Turbidity Units
Underscored Data Represent Violations of Proposed TTPI Standards (Cowan and Clayshulte, 1980).

Table 17. Marine salinity values: Koror, Palau.

SITE No.	DESCRIPTION	TTPI CLASS	SALINITY, ‰ JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	24	30	ARITHMETIC MEAN	STANDARD DEVIATION	(n)
1	PMCA: T-Dock	B	32	32	33	31	33	33	33	33	33	32	33	33	34	32.7	± 0.8	(13)
2	MOC	B	31	32	32	31	33	32	32	—	32	—	32	33	33	32.1	± 0.7	(11)
3	Palau High School	B	31	32	32	31	—	30	32	—	33	29	—	32	33	31.5	± 1.3	(10)
4	DNT Hotel: T-Dock	B	32	32	32	31	34	32	32	32	32	32	33	32	32	32.2	± 0.7	(13)
5	KA Dock: T-Dock	B	31	32	32	31	34	31	30	32	32	23	31	32	32	31.0	± 2.6	(13)
6	Metal Bai	A	31	32	33	32	33	32	32	—	32	—	32	32	—	32.1	± 0.6	(10)
7	M-Dock	B	32	33	32	32	33	32	32	—	32	32	33	32	32	32.2	± 0.5	(12)
8	Community Club	B	31	32	32	32	32	32	—	32	32	32	32	32	33	32.0	± 0.4	(12)
9	MIC: Malakal	B	31	32	32	33	33	—	32	33	—	33	—	32	32	32.3	± 0.7	(10)
10	Fisheries: Malakal	B	32	33	31	33	33	33	33	34	—	33	32	33	33	32.8	± 0.8	(12)
11	Van Camp: Malakal	B	32	32	33	33	34	33	33	33	33	—	32	33	32	32.8	± 0.6	(12)
12	STP Outfall	B	33	—	33	33	33	—	—	33	33	—	—	33	—	33.0	± 0.0	(7)
13	STP Shore: Malakal	B	33	33	32	32	33	33	—	33	—	33	—	33	33	32.8	± 0.4	(10)
14	Weather Station	AA	31	32	—	—	33	31	—	32	—	32	—	32	32	31.9	± 0.6	(8)
15	Continental Hotel	A	30	31	31	—	32	31	—	32	32	—	—	31	33	31.4	± 0.9	(9)
														ALL DATA		32	± 1	(162)

Table 18. Tide data: Koror, Palau.

July, 1980 Day	First Time	Sample Site*	Last Time	Sample Site*	High Tide Time	High Tide Height,m	Low Tide Time	Low Tide Height,m	Sites* Violations**	Sites* Not Sampled
7	1515	3	1625	15	1503	1.4	2113	0.7	2,4,6,8,14,15	---
8	1600	1	1713	15	1632	1.4	2224	0.7	3,4,5,6,8,14,15	
9	1625	15	1727	8	1749	1.5	2328	0.7	5,6,8,10	14
12	0834	3	0906	8	0651	1.9	1350	-0.1	1,3,4,5,6	14,15
14	0920	2	1008	15	0812	1.9	1504	0.0	2,6,8,14,15	3
15	0920	8	1020	15	0847	1.9	1541	0.1	3,4,6,8,14	---
19	1300	3	1357	6	1132	1.5	1801	0.6	2,3,4,5,6	8,14,15
20	1237	5	1320	15	1228	1.4	1847	0.7	4,5,8,14,15	2,3,6
21	1431	3	1540	6	1333	1.3	1942	0.8	2,3,4,5,6,15	14
22	1445	8	1547	14	1454	1.3	2052	0.9	3,4,5,8,14	2,6,15
23	1635	8	1750	6	1617	1.3	2211	0.9	4,6,8	3,14,15
24	1640	8	1805	15	1730	1.4	2217	0.9	1,3,4,5,6,8,14,15	---
30	0830	8	0956	14	0836	2.0	1522	0.1	---	6

* Shallow water locations: sites 1-6, 8, 14 and 15.
** Violations of proposed turbidity standards (Cowan and Clayshulte, 1980).

Table 19. Marine pH values: Koror, Palau.

pH

SITE No.	DESCRIPTION	TTPI CLASS	JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	24	30	ARITHMETIC MEAN ± STANDARD DEVIATION	(n)
1	PMCA: T-Dock	B	7.4	7.8	7.9	7.7	7,2	7.8	7.6	8.0	7.7	7.9	7.6	8.3	7.9	7.8 ± 0.3	(13)
2	MOC	B	8.0	8.0	8.0	7.7	7.2	7.7	7.8	--	7.9	--	--	8.4	7.9	7.9 ± 0.3	(10)
3	Palau High School	B	7.7	7.8	8.0	7.7	--	7.5	7.8	--	8.0	7.9	--	8.4	7.9	7.9 ± 0.2	(10)
4	DNT Hotel: T-Dock	B	7.7	8.0	8.0	7.8	7.3	7.7	7.8	8.0	7.9	8.0	7.8	8.3	7.9	7.9 ± 0.2	(13)
5	KA Dock: T-Dock	B	7.8	8.1	8.0	7.8	7.2	7.6	7.9	8.0	7.9	7.9	7.9	8.2	7.9	7.9 ± 0.2	(13)
6	Metal Bai	A	7.8	7.7	7.9	7.8	7.4	7.6	7.6	--	8.0	--	8.1	8.2	--	7.8 ± 0.2	(10)
7	M-Dock	B	7.8	7.8	8.0	7.9	7.8	7.7	7.8	--	8.0	7.8	8.0	8.0	8.0	7.9 ± 0.1	(12)
8	Community Club	B	7.8	8.0	8.0	7.9	7.4	7.6	--	7.9	8.0	8.0	8.0	8.1	8.0	7.9 ± 0.2	(12)
9	MIC: Malakal	B	7.8	8.0	8.0	8.0	7.3	--	7.9	8.0	--	8.0	--	8.0	8.0	7.9 ± 0.2	(10)
10	Fisheries: Malakal	B	7.7	8.0	8.0	8.0	7.5	7.7	8.0	8.0	--	8.0	8.0	8.2	8.1	7.9 ± 0.2	(12)
11	Van Camp: Malakal	B	7.8	7.8	8.0	7.9	7.7	7.7	8.0	8.0	8.1	--	8.0	8.2	8.1	7.9 ± 0.2	(12)
12	STP Outfall	B	7.8	--	8.1	8.0	7.4	--	--	8.1	8.1	--	--	8.3	--	8.0 ± 0.3	(7)
13	STP Shore: Malakal	B	7.8	8.0	8.1	8.0	7.5	7.6	--	8.1	--	8.1	--	8.2	8.1	8.0 ± 0.2	(10)
14	Weather Station	AA	7.8	8.0	--	--	7.6	7.4	--	8.0	--	8.0	--	8.2	8.1	7.9 ± 0.3	(8)
15	Continental Hotel	A	7.8	8.0	8.2	--	7.5	7.6	--	8.0	8.0	--	--	8.2	8.0	7.9 ± 0.2	(9)
														ALL DATA		7.9 ± 0.2	(161)

Table 20. Marine water temperature data: Koror, Palau.

SITE No.	DESCRIPTION	TTPI CLASS	WATER TEMPERATURE, °C — JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	24	30	ARITHMETIC MEAN ± STANDARD DEVIATION	(n)
1	PMCA: T-Dock	B	29	29.5	31	28.5	30	30	31	30.5	31.5	28.5	29	31	29.5	29.9 ± 1.0	(13)
2	MOC	B	30	31.5	33.5	28.5	29	29.5	31	—	32	—	30.5	31.5	29	30.5 ± 1.5	(11)
3	Palau High School	B	30	31	33.5	28.5	—	29	30	—	32	28	—	33.5	29	30.4 ± 2.0	(10)
4	DNT Hotel: T-Dock	B	29.5	32	32.5	29	30	30.5	31.5	31.5	32.5	28.5	30	32.5	29	30.7 ± 1.5	(13)
5	KA Dock: T-Dock	B	30	29.5	32	28.5	29.5	29.5	30	30.5	32	27.5	31.5	30.5	29	30.0 ± 1.3	(13)
6	Metal Bai	A	30	30.5	33.5	29	30	30	30.5	—	32	—	30.5	32	—	30.8 ± 1.3	(10)
7	M-Dock	B	29	29.5	30	29	30	31	30	—	29.5	28.5	29	29	29.5	29.5 ± 0.7	(12)
8	Community Club	B	29.5	29.5	31	29	30	30.5	—	32	31.5	29	31	31.5	29.5	30.3 ± 1.1	(12)
9	MIC: Malakal	B	29	29.5	31	29.5	30	—	31	30.5	—	28.5	—	30	30	29.9 ± 0.8	(10)
10	Fisheries: Malakal	B	29	29.5	32	29.5	30	30	30.5	30	—	28.5	29	29.5	29.5	29.8 ± 0.9	(12)
11	Van Camp: Malakal	B	29	29.5	31.5	29.5	30	30	30.5	30.5	30	—	29	29.5	29.5	29.9 ± 0.7	(12)
12	STP Outfall	B	28.5	—	29.5	29.5	29.5	—	—	30	29.5	—	—	29.5	—	29.4 ± 0.4	(7)
13	STP Shore: Malakal	B	29	29.5	30	29.5	30	30	—	30.5	—	28.5	—	29.5	29.5	29.6 ± 0.6	(10)
14	Weather Station	AA	30	31.5	—	—	30	30	—	31.5	—	28.5	—	31.5	29.5	30.3 ± 1.1	(8)
15	Continental Hotel	A	30.5	30	31	—	31.5	31.5	—	31.5	31	—	—	31.5	30.5	31.0 ± 0.6	(9)
														ALL DATA		30.1 ± 1.2	(162)

Table 21. Marine dissolved oxygen (mg/ℓ) and per cent saturation data: Koror, Palau.

SITE No.	DESCRIPTION	TTPI CLASS	JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	30	GEOMETRIC MEAN/ STANDARD DEVIATION (n)	% SAT.
1	PMCA: T-Dock	B	5.9/93*	6.1/98	6.0/98	3.6/56	5.3/85	5.2/84	6.2/101	6.6/106	6.5/108	6.0/93	5.9/93	4.2/68	5.5 1.20 (12)	89
2	MOC	B	7.1/112	8.8/145	7.7/132	4.0/61	4.9/77	4.6/74	6.2/101	- -	7.5/124	- -	7.2/115	3.7/58	5.9 1.35 (10)	94
3	Palau High School	B	7.2/114	6.8/111	7.4/126	2.8/43	- -	3.6/56	5.6/90	- -	7.5/125	6.8/104	- -	3.2/50	5.3 1.49 (9)	85
4	DNT Hotel: T-Dock	B	6.0/96	7.1/117	7.1/117	3.5/54	4.6/75	5.0/80	6.1/101	5.8/96	6.0/99	5.9/91	6.3/101	3.8/60	5.5 1.25 (12)	90
5	KA Dock: T-Dock	B	7.7/121	6.4/102	6.6/109	3.9/61	5.3/86	4.5/71	6.0/95	5.2/85	5.6/93	6.6/97	8.3/135	4.6/72	5.8 1.25 (12)	92
6	Metal Bai	A	6.6/104	6.8/109	7.1/122	4.1/64	5.6/90	5.1/82	6.8/109	- -	6.2/102	- -	6.5/104	- -	6.0 1.19 (9)	98
7	M-Dock	B	- -	6.0/97	6.2/99	5.3/83	5.4/87	5.5/90	6.0/96	- -	6.2/99	5.8/90	5.7/90	5.6/90	5.8 1.05 (10)	93
8	Community Club	B	6.2/96	5.9/94	6.0/98	5.0/79	7.2/115	5.2/83	- -	5.6/93	6.6/109	5.9/93	6.2/101	6.8/110	6.0 1.12 (11)	96
9	MIC: Malakal	B	6.2/96	6.5/104	6.1/100	4.6/74	5.3/85	- -	5.6/91	5.6/90	- -	6.2/96	- -	- -	5.7 1.12 (8)	91
10	Fisheries: Malakal	B	6.1/96	6.0/97	6.4/105	5.6/90	5.6/91	5.5/89	5.6/90	5.7/92	- -	6.0/93	5.9/94	5.6/90	5.8 1.05 (11)	93
11	Van Camp: Malakal	B	6.2/97	6.5/104	6.2/103	5.3/85	5.4/88	5.8/93	5.8/93	5.6/90	6.0/97	- -	6.4/101	5.7/91	5.9 1.07 (11)	95
12	STP Outfall	B	5.9/91	- -	6.4/103	6.0/97	5.8/93	- -	- -	6.1/98	6.2/100	- -	- -	- -	6.1 1.04 (6)	96
13	STP Shore: Malakal	B	6.5/102	6.2/100	6.5/104	5.7/91	5.9/95	5.9/95	- -	6.7/108	- -	7.1/110	- -	4.3/69	6.0 1.16 (9)	97
14	Weather Station	AA	6.9/109	6.9/114	- -	- -	4.7/76	4.4/69	- -	5.7/94	- -	5.9/91	- -	4.4/70	5.5 1.22 (7)	88
15	Continental Hotel	A	7.2/114	7.1/112	6.9/112	- -	6.3/104	6.4/105	- -	6.5/107	5.6/91	- -	- -	5.5/89	6.4 1.11 (8)	103
															ALL DATA 5.8 1.20(145)	93

*Data presented as: dissolved oxygen/per cent saturation.

Underscored data represent violations of TTPI standards (Class AA ≥ 6.0 mg/ℓ or 75% of saturation, whichever is greater; Class A ≥ 5.0 mg/ℓ; Class B ≥ 4.5 mg/ℓ).

Table 22. Marine sampling schedule: Koror, Palau.

SITE No.	DESCRIPTION	TTPI CLASS	SAMPLING TIME JULY, 1980 DATE 7	8	9	12	14	15	19	20	21	22	23	24	30
1	PMCA: T-Dock	B	1537	1600	1649	0854	0934	0952	1324	1250	1500	1515	1732	1745	0904
2	MOC	B	1520	1629	1711	0839	0920	0935	1307	—	1439	—	1648	1730	0851
3	Palau High School	B	1515	1638	1717	0834	—	0930	1300	—	1431	1455	—	1724	0845
4	DNT Hotel: T-Dock	B	1530	1606	1645	0849	0930	0948	1319	1244	1505	1510	1726	1740	0900
5	KA Dock: T-Dock	B	1520	1617	1703	0844	0924	0942	1315	1237	1449	1500	1700	1735	0855
6	Metal Bai	A	1550	1645	1722	0901	0949	1007	1357	—	1540	—	1750	1715	—
7	M-Dock	B	1645	1722	1615	0913	1017	1029	1407	—	1550	1612	1808	1751	1000
8	Community Club	B	1557	1650	1727	0906	0955	0920	—	1302	1425	1445	1635	1640	0830
9	MIC: Malakal	B	1435	1534	1542	0807	0857	—	1418	1211	—	1606	—	1648	1020
10	Fisheries: Malakal	B	1420	1525	1537	0800	0853	0910	1411	1205	—	1604	1621	1652	1015
11	Van Camp: Malakal	B	1440	1540	1547	0811	0847	0907	1417	1215	1410	—	1626	1655	1013
12	STP Outfall	B	1455	—	1602	0820	0906	—	—	1224	1415	—	—	1705	—
13	STP Shore: Malakal	B	1450	1547	1553	0816	0902	0914	—	1219	—	1600	—	1700	1006
14	Weather Station	AA	1613	1705	—	—	1001	1013	—	1314	—	1547	—	1800	0956
15	Continental Hotel	A	1625	1713	1625	—	1008	1020	—	1320	1530	—	—	1805	0942

Table 23. Marine fecal coliform densities: Kolonia, Ponape.

FECAL COLIFORM, #/100ml

SITE No.	DESCRIPTION	DECEMBER, 1980 DATE 15	16	18	19	22	24	29	30	31	JANUARY, 1981 DATE 5	6	8	9	GEOMETRIC MEAN	STANDARD DEVIATION	(n)
1	Sokehs Powe School	--	--	--	--	--	--	--	>600	*	--	--	--	--	--	--	(1)
2	Ekilis Hotel	130	380	9500	3700	120	100	49	5000	--	900	430	40	80	369	6.55	(12)
3	Kohler's Hotel	180	190	325	1100	<10	180	74	>6000	--	1800	765	1200	350	365	5.29	(12)
4	Nanmadol Hotel	<10	0	>60	20	<10	25	0	30	--	120	30	10	40	15	4.35	(12)
5	South Park Hotel	10	0	10	55	1	40	2	50	--	50	<10	59	35	13	4.81	(12)
6	Lidakiki	--	--	--	--	--	--	--	1800	--	150	--	--	--	520	5.75	(2)
7	Club Kolonia	90	20	--	--	--	--	--	>600	--	--	--	--	--	103	5.47	(3)
8	Fish Market	90	120	1070	12800	400	100	40	4000	--	440	1250	40	4000	457	6.89	(12)
9	Carlos Etscheit	--	--	9400	5000	4500	590	90	>6000	--	440	950	100	500	1035	5.41	(10)
DS	Dewenne Stream	7800	<100	800	2300	10700	915	70	900	--	6000	100	6000	>10900	1344	6.62	(12)
12	Dekehtik	<10	2	12	80	<10	180	<10	30	--	30	<10	80	10	19	3.46	(12)
13	Komwonlaid	310	30	12900	1000	40	680	30	>600	--	800	300	600	2100	402	6.05	(12)
14	STP Outfall	<10	16	>60	80	<10	1790	4	6000	--	>600	400	50	>12700	139	14.15	(12)
PH	Pohnpei Hotel	--	4	61	130	--	--	10	--	--	1400	<10	6300	4100	136	17.99	(8)

*Power outage, analysis terminated.
Underscored data represent violations of TTPI Class B standard (<400/100ml).

Table 24. Marine total coliform densities: Kolonia, Ponape.

TOTAL COLIFORM, #/100ml

SITE No.	DESCRIPTION	DECEMBER, 1980 DATE 15	16	18	19	22	24	29	30	31	JANUARY, 1981 DATE 5	6	8	9	GEOMETRIC MEAN	STANDARD DEVIATION	(n)
1	Sokehs Powe School	--	--	--	--	--	--	--	conf*	**	--	--	--	--	--	--	--
2	Ekilis Hotel	140	530	7800	4200	210	250	180	1800	--	880	400	635	80	548	4.02	(12)
3	Kohler's Hotel	260	200	1300	1700	40	300	120	40	--	2800	950	2600	770	426	4.48	(12)
4	Nanmadol Hotel	<10	0	>80	150	10	20	3	140	--	310	120	160	100	37	6.18	(12)
5	South Park Hotel	<10	5	3	60	1	28	7	160	--	80	100	63	70	22	5.08	(12)
6	Lidakiki	--	--	--	--	--	--	--	700	--	370	--	--	--	509	1.57	(2)
7	Club Kolonia	70	50	--	--	--	--	--	10	--	--	--	--	--	33	2.83	(3)
8	Fish Market	110	270	630	11100	1425	280	250	1000	--	1600	1050	320	4100	773	3.72	(12)
9	Carlos Etscheit	--	--	7600	5600	2205	650	600	40	--	2000	3700	2000	620	1297	4.56	(10)
DS	Dewenne Stream	>13500	<100	2100	5500	3400	2600	150	600	--	6000	8700	7400	>11500	2484	5.18	(12)
12	Dekehtik	10	108	9	290	<10	1120	2000	200	--	100	1190	400	100	141	6.65	(12)
13	Komwonlaid	210	20	3000	1560	60	300	250	300	--	1500	1100	3100	2100	506	4.98	(12)
14	STP Outfall	<10	38	1140	130	<10	300	10	7400	--	500	300	121	7700	186	10.46	(12)
PH	Pohnpei Hotel	--	1	41	15	--	--	7	--	--	600	1025	9300	8100	145	29.41	(8)

*Conf = Confluent Growth
**Power Outage, Analysis Terminated

Table 25. Marine turbidity levels: Kolonia, Ponape.

SITE No.	DESCRIPTION	TURBIDITY, NTU* DECEMBER, 1980 DATE 15	16	18	19	22	24	29	30	31	JANUARY, 1981 DATE 5	6	8	9	Geometric MEAN	STANDARD DEVIATION	(n)
1	Sokehs Powe School	—	—	—	—	—	—	—	13	3.7	—	—	—	—	6.9	2.43	(2)
2	Ekilis Hotel	3.7	6.7	5.4	8.3	5.9	4.2	11.	41.	4.1	7.8	3.8	3.3	5.6	6.4	1.94	(13)
3	Kohler's Hotel	4.5	8.0	3.5	4.0	5.6	4.8	8.5	40.	6.3	2.0	14.	12.	5.4	6.7	2.11	(13)
4	Nanmadol Hotel	1.6	2.3	1.7	6.3	2.8	2.3	2.3	4.7	1.8	3.4	2.4	2.2	2.2	2.6	1.48	(13)
5	South Park Hotel	0.7	1.4	1.0	2.2	1.2	1.3	1.2	0.8	0.8	1.3	1.4	3.2	2.6	1.3	1.58	(13)
6	Lidakiki	—	—	—	—	—	—	—	4.8	3.3	2.1	—	—	—	3.2	1.51	(3)
7	Club Kolonia	2.8	4.5	—	—	—	—	—	21.	6.1	—	—	—	—	6.3	2.36	(4)
8	Fish Market	2.8	3.8	8.9	22.	4.7	4.6	3.9	17.	12.	3.8	5.6	9.1	10.	6.8	1.90	(13)
9	Carlos Etscheit	—	—	9.1	14.	4.9	2.9	4.3	47.	8.3	3.7	6.0	6.9	14.	7.8	2.19	(11)
DS	Dewenne Stream	4.3	2.8	14.	22.	11.	2.8	2.6	6.7	5.9	10.	9.8	12.	12.	7.3	2.00	(13)
12	Dekehtik	0.8	0.9	1.8	4.7	2.0	1.2	1.2	1.3	0.8	2.3	2.2	1.8	2.0	1.6	1.65	(13)
13	Konwonlaid	7.5	8.0	13.	13.	9.8	33.	11.	140.	9.8	15.	3.6	15.	34.	14.6	2.46	(13)
14	STP Outfall	1.0	1.9	2.0	1.7	1.6	1.5	2.4	3.5	2.3	2.4	2.7	1.0	2.1	1.9	1.44	(13)
PH	Pohnpei Hotel	—	1.3	1.5	2.8	—	—	1.1	—	—	4.0	4.6	1.2	2.9	2.1	1.77	(8)
													ALL DATA		4.2	2.64	(145)

* NTU = Nephelometric Turbidity Units

_____ Underscored data represent violations of proposed TTPI standard (Cowan and Clayshulte, 1980)

Table 26. Marine salinity values: Kolonia, Ponape.

SITE No.	DESCRIPTION	SALINITY, ‰ DECEMBER, 1980 DATE 15	16	18	19	22	24	29	30	31	JANUARY, 1981 DATE 5	6	8	9	GEOMETRIC MEAN	STANDARD DEVIATION	(n)
1	Sokehs Powe School	–	–	–	–	–	–	–	28	30	–	–	–	–	29.0	1.05	(2)
2	Ekilis Hotel	–	31	26	19	28	31	30	28	23	23	28	30	28	26.8	1.16	(12)
3	Kohler's Hotel	–	32	28	31	32	30	32	21	29	24	26	28	30	28.4	1.14	(12)
4	Nanmadol Hotel	–	34	20	27	31	31	32	24	28	27	28	28	30	28.1	1.15	(12)
5	South Park Hotel	–	33	32	30	32	32	33	27	32	28	30	30	26	30.3	1.08	(12)
6	Lidakiki	–	–	–	–	–	–	–	30	28	31	–	–	–	29.6	1.05	(3)
7	Club Kolonia	–	29	–	–	–	–	–	21	15	–	–	–	–	20.9	1.39	(3)
8	Fish Market	–	29	11	13	25	27	28	23	12	14	21	26	27	20.1	1.45	(12)
9	Carlos Etscheit	–	–	10	5	24	26	26	20	11	15	17	22	28	16.7	1.70	(11)
DS	Dewenne Stream	–	25	3	2	8	10	22	21	5	14	16	10	21	10.2	2.28	(12)
12	Dekehtik	–	34	32	30	33	33	34	31	33	31	30	32	32	32.1	1.04	(12)
13	Komwonlaid	–	31	17	18	28	28	30	8	22	22	26	26	20	21.8	1.45	(12)
14	STP Outfall	–	33	33	30	34	34	33	31	31	29	30	32	32	31.8	1.05	(12)
PH	Pohnpei Hotel	–	32	31	27	–	–	33	–	–	28	23	30	29	29.0	1.12	(8)
													ALL DATA		24.0	1.59	(135)

Table 27. Marine pH values: Kolonia, Ponape.

SITE No.	DESCRIPTION	pH DECEMBER, 1980 DATE 15	16	18	19	22	24	29	30	JANUARY, 1981 DATE 31	5	6	8	9	ARITHMETIC MEAN ± STANDARD DEVIATION (n)
1	Sokehs Powe School	—	—	—	—	—	—	—	7.9	8.0	—	—	—	—	8.0 ± 0.1 (2)
2	Ekilis Hotel	8.0	7.8	7.8	7.7	8.0	8.2	7.9	7.9	7.9	7.8	7.8	7.6	7.8	7.9 ± 0.2 (13)
3	Kohler's Hotel	8.0	7.7	7.8	8.1	8.0	7.7	7.8	7.9	7.9	7.6	7.7	7.6	7.7	7.8 ± 0.2 (13)
4	Nanmadol Hotel	8.0	7.9	7.8	8.3	8.0	7.6	8.0	8.0	8.0	7.6	7.8	7.6	7.9	7.9 ± 0.2 (13)
5	South Park Hotel	8.4	7.9	7.8	8.1	8.1	8.0	8.0	8.0	8.0	7.6	8.0	7.4	7.5	7.9 ± 0.3 (13)
6	Lidakiki	—	—	—	—	—	—	—	8.1	8.2	7.7	—	—	—	8.0 ± 0.3 (3)
7	Club Kolonia	8.6	8.1	—	—	—	—	—	8.2	8.0	—	—	—	—	8.2 ± 0.3 (4)
8	Fish Market	8.1	8.1	8.2	8.1	8.2	8.1	8.1	8.1	8.0	7.9	8.1	7.8	7.9	8.1 ± 0.1 (13)
9	Carlos Etscheit	—	—	8.0	8.0	8.2	8.3	8.1	8.1	7.9	8.1	8.0	7.7	8.0	8.0 ± 0.2 (11)
DS	Dewenne Stream	8.1	8.0	8.0	8.4	8.2	8.1	8.1	8.1	7.9	8.0	8.0	7.9	8.1	8.1 ± 0.1 (13)
12	Dekehtik	8.5	8.2	8.1	8.2	8.3	8.2	8.2	8.1	8.2	7.9	8.0	7.7	8.1	8.1 ± 0.2 (13)
13	Komwonlaid	8.4	8.2	7.9	8.2	8.2	8.1	8.1	8.6	8.1	7.9	8.1	7.8	8.0	8.1 ± 0.2 (13)
14	STP Outfall	8.3	8.2	8.2	8.1	8.2	8.1	8.1	8.3	8.2	7.9	8.1	7.7	8.1	8.1 ± 0.2 (13)
PH	Pohnpei Hotel	—	8.0	8.0	8.1	—	—	8.0	—	—	7.9	7.9	7.7	7.9	7.9 ± 0.1 (8)
													ALL DATA		8.0 ± 0.2 (145)

Table 28. Marine water temperature data: Kolonia, Ponape.

SITE No.	DESCRIPTION	WATER TEMPERATURE, °C DECEMBER, 1980 DATE 15	16	18	19	22	24	29	30	JANUARY, 1981 DATE 31	5	6	8	9	ARITHMETIC MEAN ± STANDARD DEVIATION (n)
1	Sokehs Powe School	—	—	—	—	—	—	—	22	26	—	—	—	—	24.0 ± 2.8 (2)
2	Ekilis Hotel	28	27.5	27.5	27.5	29	27.5	25	22	24.5	21	21	27.5	27	25.8 ± 2.8 (13)
3	Kohler's Hotel	28.5	28	27.5	28	28.5	27	24.5	21.5	25.5	21.5	27	28	27	26.3 ± 2.4 (13)
4	Nanmadol Hotel	29	28	27.5	27.5	28	27.5	25.5	22.5	26.5	22	27	27	28	26.6 ± 2.1 (13)
5	South Park Hotel	29	28	27.5	27.5	28.5	27.5	25.5	23	26	22	28.5	28	27.5	26.8 ± 2.1 (13)
6	Lidakiki	—	—	—	—	—	—	—	24	25.5	22.5	—	—	—	24.0 ± 1.5 (3)
7	Club Kolonia	28	27	—	—	—	—	—	23	25.5	—	—	—	—	25.9 ± 2.2 (4)
8	Fish Market	28	27	28	28	28.5	28	25.5	23.5	25.5	21	27	27	28	26.5 ± 2.2 (13)
9	Carlos Etscheit	—	—	28	28	28.5	27	25.5	23	24.5	21.5	27	27.5	28	26.2 ± 2.3 (11)
DS	Dewenne Stream	29	28	28	27	27.5	27	25.5	23.5	24.5	22	27	28.5	29	26.7 ± 2.2 (13)
12	Dekehtik	28	28	28	28	28	27.5	26	23.5	25.5	22	28	28	27.5	26.8 ± 2.0 (13)
13	Komwonlaid	28	27.5	27.5	28	28	27.5	26	21	26	22	27.5	27	26.5	26.3 ± 2.3 (13)
14	STP Outfall	29	28	27.5	28	28	28	25.5	25.5	25	22	28	27	28	26.9 ± 1.9 (13)
PH	Pohnpei Hotel	—	28	28	28.5	—	—	25.5	—	—	22	28.5	27.5	27.5	26.9 ± 2.2 (8)
													ALL DATA		26.4 ± 2.2 (145)

Table 29. Marine dissolved oxygen (mg/ℓ) and per cent saturation data: Kolonia, Ponape.

SITE No.	DESCRIPTION	DECEMBER, 1980 DATE 15*	16	18	19	22	24	29	JANUARY, 1981 DATE 30	31	5	6	8	9	GEOMETRIC MEAN/ STANDARD DEVIATION (n)	% SAT.
1	Sokehs Powe School	--/--	--/--	--/--	--/--	--/--	--/--	--/--	6.9/93	7.3/107	--/--	--/--	--/--	--/--	7.1/1.04 (2)	99
2	Ekilis Hotel	5.3/81**	5.5/84	6.5/97	5.7/81	8.7/134	4.5/69	5.9/85	8.3/112	7.3/99	6.5/84	7.3/102	7.7/117	6.1/90	6.5/1.21 (13)	94
3	Kohler's Hotel	5.5/85	5.4/83	6.3/95	5.7/87	6.5/100	3.4/51	6.3/90	8.5/110	5.9/86	4.7/62	5.3/78	5.5/83	5.5/82	5.6/1.23 (13)	82
4	Nanmadol Hotel	5.8/90	6.5/101	6.3/91	7.3/109	7.1/109	7.3/112	6.3/94	8.1/107	7.1/104	6.3/84	6.9/102	7.1/105	6.7/102	6.8/1.09 (13)	100
5	South Park Hotel	5.9/91	6.3/98	5.7/88	6.9/105	7.9/122	5.5/85	4.7/70	7.9/109	6.5/97	7.9/106	7.1/108	4.9/75	3.5/52	6.1/1.27 (13)	91
6	Lidakiki	--/--	--/--	--/--	--/--	--/--	--/--	--/--	7.5/106	8.3/121	7.3/100	--/--	--/--	--/--	7.7/1.07 (3)	108
7	Club Kolonia	7.5/114	7.6/113	--/--	--/--	--/--	--/--	--/--	7.7/102	8.3/120	--/--	--/--	--/--	--/--	7.8/1.05 (4)	109
8	Fish Market	8.1/123	7.3/109	7.7/106	6.3/87	8.1/119	6.3/94	7.9/115	8.1/110	6.9/108	8.1/99	8.3/118	7.9/116	6.9/103	7.5/1.10 (13)	104
9	Carlos Etscheit	--/--	--/--	7.5/103	7.9/107	8.1/119	7.1/104	7.9/113	7.3/96	8.5/107	8.1/101	8.9/124	7.9/115	7.3/110	7.8/1.07 (11)	106
DS	Dewenne Stream	7.4/111	7.8/115	8.1/106	8.5/108	7.7/104	7.5/100	8.1/113	7.3/98	7.7/94	8.3/103	7.3/101	7.9/109	7.9/117	7.8/1.05 (13)	104
12	Dekehtik	7.4/115	7.3/114	7.5/114	7.7/117	7.5/116	7.3/113	7.5/112	8.1/121	8.1/121	7.1/98	6.5/99	7.9/121	7.3/112	7.5/1.06 (13)	114
13	Komwonlaid	7.3/112	7.3/112	6.3/89	7.1/101	7.3/110	5.9/89	7.7/113	8.5/100	7.5/106	7.3/95	7.9/119	7.1/104	6.5/90	7.2/1.10 (13)	101
14	STP Outfall	7.0/110	7.3/113	7.9/122	6.9/105	7.5/117	7.1/111	7.1/111	7.3/108	7.7/111	7.9/107	7.3/111	7.5/114	6.9/106	7.3/1.05 (13)	111
PH	Pohnpei Hotel	--/--	6.5/100	6.1/93	6.5/97	--/--	--/--	6.1/91	--/--	--/--	6.3/85	5.7/73	6.7/102	4.7/72	6.0/1.12 (8)	89
														ALL DATA	6.9/1.18 (145)	98

*DO saturation values for 15 December were calculated utilizing salinity values from 16 December.
**Data presented as: dissolved oxygen/per cent saturation.
_____Underscored data represent violations of TTPI Class B standard (≥4.5 mg/ℓ).

Table 30. Marine sampling schedule: Kolonia, Ponape.

SITE No.	DESCRIPTION	DECEMBER, 1980 DATE								JANUARY, 1981 DATE				
		15	16	18	19	22	24	29	30	31	5	6	8	9
1	Sokehs Powe School	--	--	--	--	--	--	--	1025	1330	--	--	--	--
2	Ekillis Hotel	1040	1022	1535	0945	1400	0912	0920	1000	1305	0920	0920	0930	0918
3	Kohler's Hotel	1045	1029	1540	0953	1415	0917	0928	1005	1310	0925	0925	0935	0920
4	Nanmadol Hotel	1049	1040	1550	1000	1420	0925	0934	1010	1315	0930	0930	0940	0926
5	South Park Hotel	1103	1050	1600	1012	1425	0928	0945	1015	1320	0940	0940	0947	0933
6	Lidakiki	--	--	--	--	--	--	--	1040	1340	0950	--	--	--
7	Club Kolonia	1131	1127	--	--	--	--	--	1050	1348	--	--	--	--
8	Fish Market	1134	1130	1625	1040	1448	1000	1010	1055	1350	1010	1010	1015	1015
9	Carlos Etscheit	--	--	1628	1050	1455	1007	1018	1100	1358	1015	1018	1020	1022
DS	Dewenne Stream	1140	1135	1630	1044	1450	1005	1014	1103	1355	1013	1015	1017	1020
12	Dekehtik	1113	1105	1614	1025	1435	0945	0958	1035	1335	0955	0955	1000	0940
13	Komwonlaid	1124	1115	1618	1030	1442	0938	1002	1045	1345	0950	0950	0925	0910
14	STP Outfall	1107	1055	1605	1018	1430	0933	0950	1020	1325	0945	0945	0927	0935
PH	Pohnpei Hotel	--	1044	1557	1007	--	--	0940	--	--	0935	0935	0953	0930

Table 31. Public Water System data: Colonia Yap (1-4 July 1980).

No.	SITE DESCRIPTION	JULY	TOTAL COLIFORM #/100ml 1	2	3	4**	FREE RESIDUAL CHLORINE, mg/ℓ 1	2	3	4	TURBIDITY NTU*** 1	2	3	4	pH 1	2	3	4
1	WTP Influent*		<3****	550	>800	--	0	0	0	0	200	220	130	200	7.8	7.4	7.1	7.3
2	WTP Effluent		<2	0	> 21	--	1.2	2.0	4.0	0/4.0	130	91	120	200	7.6	7.2	7.2	7.4
3	Senior High School		--	1	14****	--	--	0	0.2	--	--	71	160	--	--	7.7	7.4	--
4	Junior High School		8****	17****	31	--	0.3	0	0	0	210	71	69	90	7.7	7.1	7.1	7.1
5	Samoan Housing		--	2	1	--	--	0	0	0	--	83	65	84	--	7.2	7.2	7.2
6	ESA Hotel		--	< 2****	>10	--	--	0	0	0	--	93	110	110	--	7.2	7.1	7.3
7	Balabat		--	10****	> 8	--	--	0	0	0	--	63	110	84	--	7.2	7.0	7.4
8	Rai View Hotel		--	13****	33****	--	0	0/0	0	0	60	74/56	98	110	7.9	7.2/7.6	7.0	7.2
9	Keng		--	4****	>14	--	--	0	0	0		63	74	26	--	7.6	7.2	6.6
10	Environmental Lab		19****	4	96	--	0/0	0/0	0	0	23/100	61/130	74	88	7.6/7.5	7.1/7.3	7.1	7.3

No.	SITE DESCRIPTION	JULY	WATER TEMPERATURE °C 1	2	3	4	SPECIFIC CONDUCTANCE μmhos/cm @ 25°C 1	2	3	4	SAMPLING TIME 1	2	3	4
1	WTP Influent*		27	27	26.5	26	103	108	104	88	1040	1005	0920	0745
2	WTP Effluent		27	27.5	26.5	26	123	150	136	104	1045	1007	0925	0750/1400
3	Senior High School		-	28	28	-	-	152	136	-	-	0825	0742	-
4	Junior High School		27	27	25.5	25	123	125	136	137	1115	0955	0755	0733
5	Samoan Housing		-	28.5	28	28	-	134	152	147	-	0805	0725	0707
6	ESA Hotel		-	27.5	27	27.5	-	133	120	111	-	0725	0705	0655
7	Balabat		-	28	28	27.5	-	147	156	145	-	0850	0818	0817
8	Rai View Hotel		27	27.5/27	27	27	121	143/134	138	135	1945	0700/2050	0640	0630
9	Keng		-	28	28	27	-	157	156	122	-	0910	0837	0853
10	Environmental Lab		28.5/28	28.5/28	28	28.5	154/137	140/141	148	142	1020/1910	0745/2015	0850	0840

*WTP = Water Treatment Plant
** Power Outage 0930 hours, Coliform Analyses Invalid
***NTU = Nephelometric Turbidity Units
****Too Numerous to Count Non-Coliform

Table 32a. Koror (Palau) Public Water System: 8 July - 1 August 1980.

TOTAL COLIFORM, #/100mℓ

SITE No.	Description	JULY 8	9	10	14	16	18	21	23	25	28	29	30	31	AUGUST 1
1	WTP Influent	3	3	5	0	0	10	0	0	0	200	--	0	--	0
2	WTP Effluent	3	0	0	0	0	0	0	0	0	0	--	0	--	0
3	Watermaster's House	--	2	--	0	0	0	--	--	--	--	--	0	--	--
4	Continental Hotel	0	6	0	0	0	0	0	>145	0/0	25	6/2	0/0	0/0	0/0
5	Harris Elementary School	5	0	0	--	--	0	--	0	--	0	--	0	--	0
6	PMCA: T-Dock	43	0	0	--	0	0	0	0	0	0	--	0	--	0
7	New Koror Hotel	--	--	7	0	--	0	0	0	0	7	--	1	--	--
8	Central Market	0	0	1	1	0	0	0	29	0	0	--	0	--	0
9	Environmental Lab	0	0	0	0	0	0	0	0	0	0	--	0	--	0
10	PW Garage: M-Dock	4	0	0	0	0	0	0	0	0	0	--	0	--	0
11	Burger Hut	--	--	--	--	0	0	0	0	0	1	--	2	--	0
12	Meyuns (Last House)	10	9	7	8	--	0	--	0	--	0	--	0	--	0
13	Malakal Fisheries	0	0	0	0	0	0	0	--	2	2	--	1	--	0

Table 32b. Koror (Palau) Public Water System: 8 July - 1 August 1980.

FREE RESIDUAL CHLORINE, mg/ℓ

SITE No.	Description	JULY 8	9	10	14	16	18	21	23	25	28	29	30	31	AUGUST 1
1	WTP Influent	0	0	0	0	0	0	0.1	0	0.1	0	--	0.1	--	0
2	WTP Effluent	7.5	4.2	0	3.0	6.6	3.0	2.9	5.8	4.5	1.3	--	0.3	--	5.8
3	Watermaster's House	--	3.8	--	2.0	6.9	3.0	--	--	--	--	--	1.7	--	--
4	Continental Hotel	0.8	<0.1	0	2.0	2.4	2.8	1.4	1.4	0.3/0.2	0.6	0.1/0.7	2.5/4.3	1.9/2.8	3.0/4.0
5	Harris Elementary School	1.0	1.9	0.8	--	--	4.5	--	2.8	--	2.5	--	1.7	--	2.8
6	PMCA: T-Dock	1.0	0.3	0.8	--	3.0	2.5	2.8	3.0	3.0	2.7	--	1.6	--	2.8
7	New Koror Hotel	--	--	0.7	0.5	--	3.0	2.7	3.0	3.0	2.8	--	2.2	--	--
8	Central Market	1.0	1.2	0.5	0.5	3.0	2.7	2.3	2.8	3.0	2.5	--	1.7	--	2.7
9	Environmental Lab	0.5	0.3	0.5	0.5	2.8	3.0	1.2	3.0	2.5	1.4	--	0.5	--	2.7
10	PW Garage: M-Dock	0	0	0.5	0.3	2.9	2.7	1.3	3.0	3.0	2.3	--	1.6	--	2.5
11	Burger Hut	--	--	--	--	2.8	2.1	1.9	2.8	3.0	1.2	--	2.4	--	2.0
12	Meyuns (Last House)	0	0	1.2	0.8	--	3.0	--	<0.1	--	0	--	0.1	--	0
13	Malakal Fisheries	0.1	0	1.2	0.2	0.2	2.3	0.2	--	2.7	0	--	4.5	--	1.1

Table 32c. Koror (Palau) Public Water System: 8 July - 1 August 1980.

SITE No.	Description	TURBIDITY, NTU* JULY 8	9	10	14	16	18	21	23	25	28	29	30	31	AUGUST 1
1	WTP Influent	10	8	7	15	12	10	14	12	10	7	--	6	--	6
2	WTP Effluent	7	8	6	8	9	6	8	7	6	4	--	4	--	3
3	Watermaster's House	--	7	--	10	9	7	--	--	--	--	--	4	--	--
4	Continental Hotel	9	9	9	8	9	7	8	8	7	4	4/4	4/4	4/4	4/4
5	Harris Elementary School	8	6	6	--	--	6	--	7	--	4	--	4	--	3
6	PMCA: T-Dock	8	7	6	--	12	8	8	9	7	4	--	4	--	3
7	New Koror Hotel	--	--	6	8	--	7	8	8	6	4	--	4	--	--
8	Central Market	7	6	6	8	8	6	8	7	7	4	--	4	--	3
9	Environmental Lab	7	7	6	9	11	9	14	8	8	4	--	5	--	3
10	PW Garage: M-Dock	16	10	9	17	21	20	13	12	8	6	--	5	--	5
11	Burger Hut	--	--	--	--	8	7	9	8	8	6	--	4	--	3
12	Meyuns (Last House)	9	7	6	8	--	8	--	8	--	4	--	7	--	4
13	Malakal Fisheries	15	6	7	8	22	8	8	--	7	4	--	4	--	5

* NTU = Nephelometric Turbidity Units.

Table 33a. Koror (Palau) Public Water System: 8 July - 1 August 1980.

SITE No.	Description	SAMPLING TIME JULY 8	9	10	14	16	18	21	23	25	28	29	30	31	AUGUST 1
1	WTP Influent	0850	0912	0920	1120	1004	0900	0930	0846	0850	1134	--	0940	--	0905
2	WTP Effluent	0900	0917	0935	1105	1007	0913	0933	0850	0855	1128	--	0945	--	0915
3	Watermaster's House	--	0925	--	1135	1014	0917	0936	--	0900	--	--	0955	--	0920
4	Continental Hotel	0925	1000	1005	1155	1037	0935	1000	0910	0930	1158	1045/1050	1020/1032	1345/1352	0935/0943
5	Harris Elementary School	0730	0734	0745	--	0730	0738	0753	0742	0748	0736	--	0725	--	0750
6	PMCA: T-Dock	0703	0720	0730	--	0720	0726	0741	0728	0736	0750	--	0714	--	0734
7	New Koror Hotel	--	--	0605	0705	0755	0600	0730	0714	0604	0603	--	0600	--	--
8	Central Market	0755	0745	0757	0713	0712	0715	0719	0705	0721	0800	--	0705	--	0722
9	Environmental Lab	0805	0757	0805	0724	0800	0615	0816	0759	0820	0811	--	0740	--	0809
10	PW Garage: M-Dock	0648	0700	0715	0749	0652	0705	0646	0649	0710	0717	--	0655	--	0715
11	Burger Hut	--	--	--	--	0703	0800	0713	0622	0625	0626	--	0612	--	0700
12	Meyuns (Last House)	0630	0630	0655	0635	0640	0647	0641	0635	0658	0700	--	0625	--	0655
13	Malakal Fisheries	0613	0610	0630	0615	0620	0632	0625	--	0638	0642	--	0855	--	0630

Table 33b. Koror (Palau) Public Water System: 8 July - 1 August 1980.

SPECIFIC CONDUCTANCE, μmhos/cm at 25°C

SITE No.	Description	JULY 8	9	10	14	16	18	21	23	25	28	29	30	31	AUGUST 1
1	WTP Influent	104	68	86	99	60	58	180	106	136	71	--	91	--	87
2	WTP Effluent	104	101	76	118	103	76	124	106	107	93	--	90	--	85
3	Watermaster's House	--	141	--	118	103	77	--	--	--	--	--	91	--	--
4	Continental Hotel	104	101	91	123	103	95	147	103	107	103	106/103	91/92	106/106	86/86
5	Harris Elementary School	104	101	101	--	--	109	--	106	--	110	--	111	--	86
6	PMCA: T-Dock	104	96	101	--	103	126	198	106	107	103	--	116	--	85
7	New Koror Hotel	--	--	101	99	--	155	164	106	107	116	--	113	--	--
8	Central Market	88	96	101	99	103	134	113	108	107	110	--	113	--	86
9	Environmental Lab	104	91	101	99	103	125	113	101	107	110	--	113	--	86
10	PW Garage: M-Dock	104	86	101	197	103	137	113	106	107	110	--	116	--	86
11	Burger Hut	--	--	--	--	103	145	113	110	107	110	--	114	--	86
12	Meyuns (Last House)	104	101	101	104	--	158	--	110	--	103	--	141	--	86
13	Malakal Fisheries	104	101	101	108	103	136	113	--	107	110	--	89	--	88

Table 33b. Koror (Palau) Public Water System: 8 July - 1 August 1980.

SPECIFIC CONDUCTANCE, μmhos/cm at 25°C

SITE No.	Description	JULY 8	9	10	14	16	18	21	23	25	28	29	30	31	AUGUST 1
1	WTP Influent	104	68	86	99	60	58	180	106	136	71	--	91	--	87
2	WTP Effluent	104	101	76	118	103	76	124	106	107	93	--	90	--	85
3	Watermaster's House	--	141	--	118	103	77	--	--	--	--	--	91	--	--
4	Continental Hotel	104	101	91	123	103	95	147	103	107	103	106/103	91/92	106/106	86/86
5	Harris Elementary School	104	101	101	--	--	109	--	106	--	110	--	111	--	86
6	PMCA: T-Dock	104	96	101	--	103	126	198	106	107	103	--	116	--	85
7	New Koror Hotel	--	--	101	99	--	155	164	106	107	116	--	113	--	--
8	Central Market	88	96	101	99	103	134	113	108	107	110	--	113	--	86
9	Environmental Lab	104	91	101	99	103	125	113	101	107	110	--	113	--	86
10	PW Garage: M-Dock	104	86	101	197	103	137	113	106	107	110	--	116	--	86
11	Burger Hut	--	--	--	--	103	145	113	110	107	110	--	114	--	86
12	Meyuns (Last House)	104	101	101	104	--	158	--	110	--	103	--	141	--	86
13	Malakal Fisheries	104	101	101	108	103	136	113	--	107	110	--	89	--	88

Table 34a Kolonia (Ponape) Public Water System: 13 December 1980 - 10 January 1981.

TOTAL COLIFORM, #/100 ml

SITE NO.	DESCRIPTION	DECEMBER, 1980										JANUARY, 1981		
		13	16	17	18	20	24	25	26	27	31	2	3	10
1A	WTP Filter Influent	>26*	216	460	1300	1900	660	350	4000	650	170	3400	920	--
1B	WTP Effluent	Ø	Ø*	8	31	4	2	12	6	3	3	31	Ø	--
2	Namiki	Ø	Ø	1	13	Ø	Ø	Ø*	Ø	1	22	3	7	--
3	Sokehs	Ø	Ø	2	2	1	Ø	53	58	1	2*	9	Ø	--
6	Dekehtik	1	Ø	1	6	Ø	Ø	Ø	5	Ø	14	20	1	--
7	Federation Store	3	Ø	8	13	1	4	17	19	2	52	63	3	--
8	Environmental Lab	Ø	Ø	1	13	Ø	Ø	3	1	1	1	10	Ø	--
9	Komwonlaid	Ø	Ø	1	10	Ø	Ø	Ø	29	2	Ø	Ø	10	--
10	South Park Hotel	1	Ø	Ø	8	1	1	64*	1	5	193	Confluent	3	--
PH	Pohnpei Hotel	4	Ø	Ø	Ø	Ø	Ø	11	13	Ø	--	--	7	--
VH	Village Hotel	--	--	--	--	--	--	--	--	--	--	30	360	--
4	Ngatik	--	--	--	--	--	--	--	--	--	--	--	--	Ø
5	Danpei	--	--	--	--	--	--	--	--	--	--	--	--	Ø

* Too numerous to count non-coliform.

Table 34b. Kolonia (Ponape) Public Water System: 13 December 1980 - 10 January 1981.

SITE NO.	DESCRIPTION	FECAL COLIFORM, #/100 ml												
		DECEMBER, 1980										JANUARY, 1981		
		13	16	17	18	20	24	25	26	27	31	2	3	10
1A	WTP Filter Influent	52	16	760	120	230	35	60	67	3	30	--	90	--
1B	WTP Effluent	Ø	Ø	Ø	14	Ø	Ø	Ø	Ø	Ø	Ø	--	Ø	--
2	Namiki	Ø	--	--	--	--	--	--	--	--	--	--	--	--
3	Sokehs	Ø	--	--	--	--	--	--	Ø	--	--	--	--	--
6	Dekehtik	Ø	Ø	Ø	--	Ø	Ø	Ø	--	--	--	--	--	--
7	Federation Store	Ø	Ø	--	1	Ø	Ø	Ø	Ø	--	--	--	--	--
8	Environmental Lab	Ø	--	--	--	--	--	--	--	--	--	--	Ø	--
9	Komwonlaid	Ø	--	Ø	9	Ø	Ø	Ø	Ø	--	--	--	--	--
10	South Park Hotel	Ø	Ø	Ø	--	Ø	--	Ø	Ø	--	--	--	Ø	--
PH	Pohnpei Hotel	Ø	Ø	Ø	--	--	--	--	--	--	--	--	1	--
VH	Village Hotel	--	--	--	--	--	--	--	--	--	--	--	1600	--
4	Ngatik	--	--	--	--	--	--	--	--	--	--	--	--	Ø
5	Danpei	--	--	--	--	--	--	--	--	--	--	--	--	Ø

Table 34c. Kolonia (Ponape) Public Water System: 13 December 1980 - 10 January 1981.

FREE RESIDUAL CHLORINE, mg/l

SITE NO.	DESCRIPTION	DECEMBER, 1980										JANUARY, 1981		
		13	16	17	18	20	24	25	26	27	31	2	3	10
1A	WTP Filter Influent	Ø	--	--	--	--	--	--	--	--	--	--	--	--
1B	WTP Effluent	>3	2.0	1.8	1.0	2.1	>3	>3	2.7	2.8	>3	3.0	>3	--
2	Namiki	2.8	1.6	2.4	<0.1	1.5	>3	2.8	2.2	2.8	2.4	0.7	2.5	--
3	Sokehs	2.8	0.7	1.6	0.4	2.6	3.0	1.5	1.6	2.2	1.7	1.1	1.7	--
6	Dekehtik	1.6	0.3	1.5	Ø	0.4	1.8	1.5	1.4	1.0	0.5	Ø	Ø	--
7	Federation Store	2.4	0.3	1.2	Ø	2.4	2.5	1.7	1.7	0.6	1.0	1.0	Ø	--
8	Environmental Lab	2.8	0.5	1.5	Ø	2.2	1.5	2.0	1.4	1.4	1.0	0.1	1.5	--
9	Komwonlaid	1.1	0.5	1.1	Ø	1.5	1.8	0.9	Ø	Ø	Ø	1.1	0.9	--
10	South Park Hotel	2.2	Ø	1.0	Ø	2.4	2.4	2.0	1.0	1.0	1.3	Ø	1.5	--
PH	Pohnpei Hotel	2.8	0.5	1.7	0.2	2.2	Ø	2.0	1.8	1.2	--	--	1.0	--
VH	Village Hotel	--	--	--	--	--	--	--	--	--	--	Ø	Ø	--
4	Ngatik	--	--	--	--	--	--	--	--	--	--	--	--	1.8
5	Danpei	--	--	--	--	--	--	--	--	--	--	--	--	2.0

Table 35a. Kolonia (Ponape) Public Water System: 13 December 1980 - 10 January 1981.

TURBIDITY, NTU*

SITE NO.	DESCRIPTION	DECEMBER, 1980										JANUARY, 1981		
		13	16	17	18	20	24	25	26	27	31	2	3	10
1A	WTP Filter Influent	1.3	1.3	11.	3.8	3.5	1.0	1.0	1.2	1.2	1.9	3.5	1.3	--
1B	WTP Effluent	0.8	0.8	3.3	2.4	1.8	0.6	0.6	0.6	0.7	0.9	2.8	0.8	--
2	Namiki	0.9	0.7	0.9	1.9	1.3	1.2	0.6	0.6	0.7	0.9	1.8	0.9	--
3	Sokehs	0.7	0.8	0.6	1.9	1.4	0.6	0.7	0.7	0.6	1.0	0.8	0.8	--
6	Dekehtik	1.0	1.0	0.7	1.9	1.2	0.7	2.7	1.4	0.7	0.6	1.0	0.8	--
7	Federation Store	0.9	0.9	0.7	2.6	0.8	0.8	1.2	2.7	1.4	1.4	0.8	1.5	--
8	Environmental Lab	1.0	1.0	0.6	2.2	1.0	0.6	0.7	0.7	0.8	1.3	0.8	1.0	--
9	Komwonlaid	0.8	1.0	0.8	1.6	0.9	1.0	0.9	1.0	1.6	1.9	1.0	0.9	--
10	South Park Hotel	0.8	0.8	0.7	1.6	0.8	0.7	0.6	0.6	0.8	1.1	1.0	0.9	--
PH	Pohnpei Hotel	0.7	0.7	0.6	1.6	1.0	1.1	0.6	0.7	0.7	--	--	0.8	--
VH	Village Hotel	--	--	--	--	--	--	--	--	--	--	4.1	4.3	--
4	Ngatik	--	--	--	--	--	--	--	--	--	--	--	--	1.2
5	Danpei	--	--	--	--	--	--	--	--	--	--	--	--	0.7

*NTU = Nephelometric Turbidity Units

Table 35b. Kolonia (Ponape) Public Water System: 13 December 1980 - 10 January 1981.

pH

SITE NO.	DESCRIPTION	DECEMBER, 1980										JANUARY, 1981		
		13	16	17	18	20	24	25	26	27	31	2	3	10
1A	WTP Filter Influent	7.6	7.9	7.8	7.8	8.0	8.4	7.6	7.6	7.6	7.6	7.3	7.4	--
1B	WTP Effluent	7.3	7.7	7.6	7.6	7.6	8.1	7.7	7.5	7.5	7.5	7.2	7.6	--
2	Namiki	7.3	7.6	7.7	7.7	7.7	8.1	7.9	7.7	7.6	7.2	7.3	7.5	--
3	Sokehs	7.5	7.6	7.6	7.7	7.7	7.8	7.7	7.6	7.6	7.4	7.4	7.4	--
6	Dekehtik	8.6	8.4	7.8	7.8	8.2	8.2	7.8	8.5	8.5	8.2	8.4	8.5	--
7	Federation Store	7.3	8.7	8.2	8.2	7.9	8.5	8.2	8.6	8.4	8.1	8.4	8.6	--
8	Environmental Lab	7.4	8.0	8.1	8.1	8.0	8.3	8.1	8.2	8.1	7.9	8.3	8.2	--
9	Komwonlaid	7.5	7.9	8.0	7.9	8.0	8.1	7.8	8.0	7.9	7.8	8.0	8.0	--
10	South Park Hotel	7.3	7.8	7.8	7.8	7.6	8.0	7.8	7.9	7.8	8.8	7.8	7.9	--
PH	Pohnpei Hotel	7.3	7.8	7.6	7.7	7.6	7.9	7.7	7.8	7.6	--	--	7.8	--
VH	Village Hotel	--	--	--	--	--	--	--	--	--	--	7.4	7.1	--
4	Ngatik	--	--	--	--	--	--	--	--	--	--	--	--	9.8
5	Danpei	--	--	--	--	--	--	--	--	--	--	--	--	8.5

Table 36a. Kolonia (Ponape) Public Water System. 13 December 1980 - 10 January 1981.

SPECIFIC CONDUCTANCE, μmhos/cm at 25°C

SITE NO.	DESCRIPTION	DECEMBER, 1980										JANUARY, 1981		
		13	16	17	18	20	24	25	26	27	31	2	3	10
1A	WTP Filter Influent	--	35	22	25	23	25	25	25	25	25	24	23	--
1B	WTP Effluent	--	16	40	34	34	45	25	25	40	35	41	40	--
2	Namiki	--	21	42	35	35	44	39	40	40	36	39	35	--
3	Sokehs	--	38	42	40	41	44	40	41	40	38	42	38	--
6	Dekehtik	--	43	45	52	50	50	45	55	55	49	60	60	--
7	Federation Store	--	45	48	52	42	50	50	44	50	44	44	49	--
8	Environmental Lab	--	39	40	43	44	39	44	58	45	42	48	45	--
9	Komwonlaid	--	35	50	45	45	44	48	50	48	43	44	43	--
10	South Park Hotel	--	39	42	43	42	37	44	40	40	39	45	40	--
PH	Pohnpei Hotel	--	28	40	42	45	44	40	40	40	--	--	40	--
VH	Village Hotel	--	--	--	--	--	--	--	--	--	--	100	110	--
4	Ngatik	--	--	--	--	--	--	--	--	--	--	--	--	110
5	Danpei	--	--	--	--	--	--	--	--	--	--	--	--	45

Table 36b. Kolonia (Ponape) Public Water System: 13 December 1980 - 10 January 1981.

SITE NO.	DESCRIPTION	SAMPLING TIME												
		DECEMBER, 1980										JANUARY, 1981		
		13	16	17	18	20	24	25	26	27	31	2	3	10
1A	WTP Filter Influent	1030	1542	1425	1020	1315	1300	1135	1133	1100	1045	0900	1125	--
1B	WTP Effluent	1035	1547	1430	1028	1320	1305	1140	1135	1105	1048	0905	1130	--
2	Namiki	1155	1700	1408	1000	1415	1243	1120	1110	1040	1025	0845	1045	--
3	Sokehs	1055	1614	1454	1110	1345	1330	1205	1155	1125	1105	0930	1105	--
6	Dekehtik	1220	1727	1615	1215	1515	1505	1305	1300	1240	1200	1030	1245	--
7	Federation Store	1235	1740	1357	0950	1505	1233	1105	1055	1030	1015	0830	1030	--
8	Environmental Lab	1250	1800	1635	1300	1700	1450	1330	1330	1300	1230	1100	1315	--
9	Komwonlaid	1205	1709	1545	1200	1545	1455	1250	1245	1215	1140	1010	1225	--
10	South Park Hotel	1145	1645	1530	1140	1443	1400	1230	1225	1155	1120	0950	1205	--
PH	Pohnpei Hotel	1115	1635	1517	1130	1425	1345	1220	1210	1140	--	--	1155	--
VH	Village Hotel	--	--	--	--	--	--	--	--	--	--	1130	1530	--
4	Ngatik	--	--	--	--	--	--	--	--	--	--	--	--	1620
5	Danpei	--	--	--	--	--	--	--	--	--	--	--	--	1750