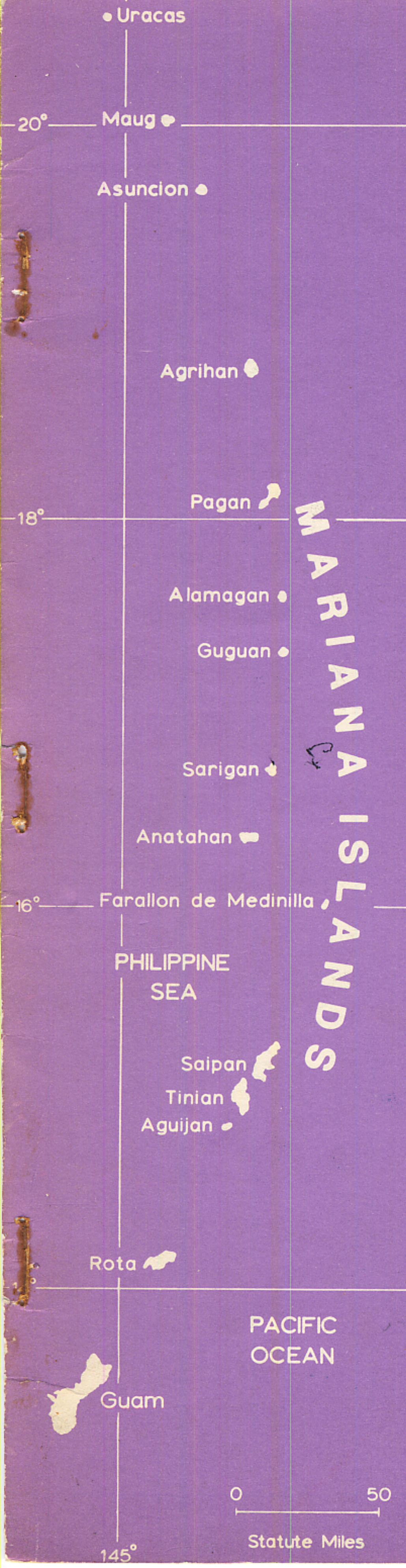

AIR, NOISE, AND WATER QUALITY MONITORING PROGRAM AIRPORT CONSTRUCTION SITE MOEN ISLAND TRUK DISTRICT TRUST TERRITORY OF THE PACIFIC ISLANDS PART A PRE-CONSTRUCTION

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Water Resources Research Center

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Technical Report No. 7

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CONTRACT NO. N62742-78-C-0029, PART A

Department of the Navy

Pacific Division

Naval Facilities Engineering Command

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The existing runway at the Truk International Airport on Moen Island (Fig. 1) will be lengthened and widened to provide capability for supporting existing and forecast air transportation requirements and for handling medium range jet aircraft without operating restrictions or safety hazards. The 5,100 feet long runway will be repositioned approximately 150 feet northwest so that the new runway centerline coincides with the northeast edge of the existing runway and extended to 6,000 feet long. The runway fill area will be extended 1,400 feet southwest and 600 feet northeast. The runway extensions into the Truk Lagoon will consist of protective embankment and dredged coral fill. Basaltic rock obtained from the existing upland quarry near the northeast end of the existing runway will be used for the protective embankment. Approximately 2,100,000 cubic yards of dredged coral material will be used as fill for the airport extension.

This study of air, noise, and water quality prior to construction was requested by the U.S. Navy in accordance with Contract No. N62742-78-C-0029, Part A. It is a portion of the first part of a three part environmental monitoring program which will consist of:

1. Part A. Pre-Construction Monitoring Program

2. Part B. Construction Monitoring Program

3. Part C. Post-Construction Monitoring Program

Each of these parts is further divided into two portions, a water (and, for Part A, noise and air) quality monitoring program and a biological monitoring program. The biological monitoring program is being undertaken by the Marine Laboratory of the University of Guam and is described in a separate report.

OBJECTIVES

The objectives of this study are to:

1. Obtain, prior to construction, air, noise, and/or water quality information for the airport, rock quarry, and dredging/dragline sites.

2. Develop turbidity limits to be used for controlling changes caused by construction activity.

SCOPE

In order to accomplish the objectives of this study, the Water Resources Research Center was directed to:

1. In coordination with the Trust Territory Environmental Projection Board (TTEPB), establish eight water sampling stations, two air sampling stations and three noise monitoring stations.

2. Conduct on-site surveys and adequate field and laboratory studies to obtain measurements of the following parameters at the applicable stations cited in the preceding paragraph:

    a. Air: airborne particulates.

    b. Noise: background noise.

    c. Water: turbidity, dissolved oxygen, temperature, pH, total nitrogen, total phosphorus, salinity, mercury, zinc, copper, arsenic, and lead.

3. Compile and summarize the air, noise, and water quality data using statistical methods when applicable to establish a baseline for each and all stations. Indicate the effect of tidal change, time of day, and water depth on the water quality of the study area.

4. Develop limits for turbidity to control changes caused by construction activity. Provide detailed justification and rationale for the turbidity limits recommended.

The project limits for the airport construction site and dredge area are shown in figures 2 and 3. Also shown in these figures is the "water quality boundary" which is located about 200 feet outside of the project limits. All water sampling stations are outside of this boundary where waters are not to be degraded to below the standards of water quality for the Trust Territory of the Pacific Islands. Specific water sampling stations, as well as air sampling stations and noise monitoring stations, are also shown in figures 2 and 3.

METHODS

Water Quality Monitoring

Site Selection Criteria

The following criteria were utilized in the selection of water sampling stations:

1. The establishment of stations beyond the water quality boundary:

   a. along the reef margins of the proposed dredge sites, including sites considered as possible alternatives.

   b. at major runway expansion areas.

2. The selection of an easily relocatable topographical feature (rubble mound or coral/rock pinnacle).

3. The establishment of a control monitoring station away from construction influence that could be routinely monitored to assess long term natural water quality fluctuations.

Station Descriptions

Nine water quality monitoring stations were established based on the site selection criteria. Small red or white bouys were secured by a length of rope at the monitoring stations to facilitate relocation. Additionally, key land marks were recorded for orientation. Locations of the stations follow (see Appendix for detailed station descriptions):

Station 1 - is east of Pou Channel on a prominent outcropping of the East Pou Reef margin (Fig. 3) at an average depth of 8m.

Station 2 - is west of Pou Channel on a major extension of West Pou Reef (Fig. 3) at an average depth of 7m.

Station 3 - is off the arm east of the large indentation on the West Pou Reef margin (Fig. 3) at an average depth of 8m.

Station 4 - is off the arm west of the large indentation on the West Pou Reef margin (Fig. 3) at a depth of 7m.

Station 5 - is off the reef margin across from the center of the Metitiu Reef dredge area (Fig. 3) at a depth of 9m.

Station 6 - is west of Metitiu Reef off the northeast end of the runway on a coral rubble mound (Fig. 2) at a depth of 7m.

Station 7 - is off the central portion of the runway (Fig. 2) at a depth of 9m.

Station 8 - is off (north) the southwestern end of the runway in the vicinity of the Point Gabert sewer outfall diffuser on a low rubble mound (Fig. 2) at a depth of 12m.

Station 9 - is on the eastern side of a large patch reef that lies approximately half-way between Moen and Fano Islands (Fig. 3) at a depth of 7m.

Chemical and Physical Analyses

Water quality parameters were measured at eight stations selected just outside the water quality boundary and at one station located about one kilometer off Pou Bay to act as a control.

The water quality parameters measured during the study were turbidity, dissolved oxygen, temperature, salinity, pH, total nitrogen, total phosphorus and the heavy metals: zinc, copper, lead, mercury, and arsenic. Table 1 presents the methods of analysis used for each parameter.

Water samples were collected by van Dorn water sampler and taken to either the Health and Sanitation Laboratory on Moen for analysis or to the Water Resources Research Center Laboratory on Guam. Salinity was measured in situ by probe. Temperature was measured by mercury thermometer or in situ by probe.

Technical problems with the dissolved oxygen meter and pH meter made it necessary to use alternative standard methods of analyses for these parameters other than those prescribed by the contract scope of work. The azide modification of the winkler titration was used to obtain dissolved oxygen measurements. pH samples were taken back to the Health and Sanitation Lab for probe readings because the meter needle proved unstable on board the sampling vessel.

Turbidity in the study area along the water quality boundary was such that the use of a secchi disk was impractical. On every sampling date and nearly at every station the lagoon bottom was clearly visible to those aboard the sampling vessel. In fact, stations were located by finding particular submerged coral mounds which were selected as station markers. The clarity of the waters was such that coral and fish could be recognized on the bottom, on many occasions.

For this reason, nephelometry was used in place of the secchi disk to obtain turbidity data. A Hach model 2100A turbidimeter was used to analyze surface and bottom samples taken from the eight water sampling stations and control station.

At the control station, well outside the water quality boundary, additional turbidity data were collected to compare with the water quality stations along the water quality boundary.

Modifications of the prescribed sampling and analyses procedures also included the use of an optical refractometer to check in situ salinometer probe readings which were lower than expected.

One set of samples analyzed for heavy metals (Zn, Cu, Pb, Hg, and As) was collected on the June 26, 1978 sampling from each station at 5 meter depths. The samples were preserved with nitric acid and brought back to Guam for analysis by the U.S. Navy Public Works Center, Fena Laboratory.

Air Quality Monitoring

Two sites were selected for air quality monitoring. One site was located on the grounds of the weather station (Fig. 2) atop a water tank. This station is sufficiently close to the airport runway to be affected by take off and landing operations as well as road dust from surrounding village roads. The other site was located across from the from the Metitiu Quarry. The sampler was placed atop a one-story house next to the lagoon shore.

Suspended particulates were monitored for a continuous seven-day period from June 20 to June 27, 1978 at sites likely to be affected by airport construction work. Standard high volume air samplers with housings were used. The flow rate of each sampler was between 40 to 60 m^3/min. The total accumulated weight of suspended particulates was divided by the total cubic meters of air drawn in 24 hours to arrive at weight of suspended particulate matter per cubic meter of air. The daily data were used to compute a geometric mean for each site.

Noise Quality Monitoring

Three sites likely to be affected by airport runway construction and related reef dredging operations were selected for 24-hour sound measurement surveys. One 24-hour survey was completed for each site. The entire sound measurement survey was conducted from Tuesday 8:00 p.m. June 20, 1978 through Friday 10:00 p.m. June 23, 1978. The sites chosen for study included the Airport Terminal area, Metitiu Quarry east of the runway, and a rock jetty at the Pou Bay Causeway. At each site a location for the precision sound level meter was selected to minimize acoustical shielding or noise build up from related structures and also to minimize localized background noise from human related activities.

The Airport Terminal measurement site was located in the middle of the open lawn in front of the terminal with the microphone oriented parallel to the runway (068°-ENE) in order to collect both airport noises and urban noises from the nearby village.

The Metitiu Quarry measurement site was located in an open area across the road directly in front of the rock crusher and about 10 meters from the lagoon. The microphone was pointed toward the airport runway (270°- due west) perpendicular to the road fronting Metitiu Quarry.

The Pou Bay measurement site was located at the end of the rock jetty which is perpendicular to the Causeway. The microphone was pointed toward the intended reef dredge area (296-304°) parallel to the Causeway.

A Bruel and Kjaver type 2209 sound level meter was used to gather all sound pressure readings. The octave filter set, type 1613, was only used to determine the frequency distribution of insect and crustacean noises at the Pou Bay Causeway.

The meter was equipped with a microphone, B & K type 4145, and fitted with a windscreen. The microphone was attached to a tripod and with the use of a cable was placed 2.4 - 3m from the sound level meter.

Data were gathered by continuous manual readings of the sound level meter. No recorders were available. Two types of sound level information were gathered: Broad band-slow response and broad band-peak hold. The slow response meter function was A weighted.

Each station was monitored over a 24-hour period with one-half of each hour devoted to monitoring slow response. During this period, a reading was taken every five minutes, starting with the half-hour mark and terminating on the hour. Notes were taken to identify the noise producer when sound levels rose in response to identifiable human activities or other natural phenomena.

During the remaining half-hour of each hour the sound level meter function was set to peak hold and the peak decibel reading for the one-half hour duration was obtained. The causes for the peak readings were noted as they occurred.

Meteorological Data

Weather data including wind speed and direction, air temperature, water temperature, total sunshine, barometric pressure, and precipitation were obtained from the U.S. Department of Commerce, National Weather Station, Moen, Truk. Hourly readings were recorded and the 24-hour average was computed for each meteorological parameter (Tables 2 and 3).

RESULTS AND DISCUSSION

Water Quality Monitoring

Turbidity

Turbidity (in NTU) ranged from 0.15 to 1.5 at the eight water sampling stations. Only two readings of the 147 samples taken at these stations exceeded 1.0 NTU. Both of these samples were bottom samples. However, a comparison of the mean and standard deviation of the bottom samples versus surface samples reveals no significant difference between them. The mean bottom turbidity for all eight stations was 0.41 NTU with a standard deviation of 0.18. The surface samples had mean turbidity of 0.39 NTU with a standard deviation of 0.13. When all turbidity readings are averaged, the resultant mean is 0.40 NTU with a standard deviation of 0.16 (Table 4). When the turbidity data is plotted on probability paper, the similarity of data from the stations is evident (Fig. 4). The geometric mean turbidity from the probability distribution is 0.37 NTU. The clustering of values in the 0.20 - 0.50 NTU range is shown in the bar graph (Fig. 5).

The only station which shows a significant difference from other stations is station 6 which is significantly different from stations 3 and 8 at the .05 significance level. Station 6 is significantly less turbid than stations 3 and 8 but the total difference in means is less than 0.2 NTU. No other significant differences exist at the .05 significance level for any other comparison of station turbidity.

Turbidity readings from the control sampling site (Station 9) reveal lower turbidity than the water monitoring stations. The control site is located well out from terrestrial influences of Moen and is more representative of open lagoon waters. The mean turbidity of station 9 was 0.24 NTU (Table 4).

The relatively high standard deviation (as a percent of mean turbidity) of most stations indicates the fluctuations in turbidity that can be expected in conditions ranging from calm seas to squalls and stormy weather since these conditions were encountered during the sampling program.

The influence of tidal change on turbidity levels was statistically analyzed by comparing readings obtained during rising, slack, and falling tides (Table 5). The mean turbidities of the stations during rising tides ranged from 0.25 NTU (Station 9) to 0.47 NTU (Station 2). The mean turbidities of the stations during falling tides ranged from 0.31 NTU (Station 2) to 0.45 NTU (Station 8). Slack tide turbidities had the widest variation in mean turbidities ranging from 0.23 NTU (Station 9) to 0.63 NTU (Station 3). The grand mean for rising tide turbidity was 0.38 NTU, based on 43 readings and 0.37 NTU for falling tides, based on 74 readings. A comparison of the grand means of all stations during rising, falling, and slack tide conditions showed no significant difference.

Temperature

Water temperatures within the study area ranged from 28.6 to 30.1°C (standard deviation of 0.4°C). Surface temperatures were about 0.5°C warmer than bottom or mid-depth temperatures on days with predominantly sunny skies. On the July 21st and August 4th sampling dates, when overcast skies predominated, surface and bottom temperatures were more uniform (Table 6). Based on the results obtained, temperatures in the study area can be expected to fall within one degree of 29.4°C centigrade with predominant factors in temperature being amount of sunlight and time of day.

pH

The pH within the water quality zone ranged from 8.08 to 8.28. The mean value was 8.21 for all stations and depths. No significant differences were detected between the sampling site pH values (Table 7). The pH of waters in the water quality zone should usually fall within the range 8.2 ± 0.2 pH units.

Salinity

Salinity values obtained from both in situ probe and refractometer readings for surface (-1m) and bottom (+1 to 2m) waters are presented in Table 8. Mean salinity values ranged from 33.0 ppt (Station 8, bottom) to 34.1 ppt (Station 9, bottom). The mean values of lagoon waters at stations 1 through 8 are lower than normal oceanic salinity. This indicates that the near island lagoon waters are influenced by terrestrial runoff. Salinity at station 9 is more indicative of open water lagoon salinity.

The lower salinities recorded for station 8 are probably a result of a dilution caused by effluent discharge from the Point Gabert sewer outfall. Surface salinities ranged from 31.5 to 35.0 ppt with a mean of 33.2 ± 1.5 ppt. Bottom salinities ranged from 29.2 to 35.5 ppt. These values are consistent with those obtained in the Point Gabert sewer outfall study (Tsuda et al., 1975). Salinities in the 1975 study for surface water 30m away from the diffuser site ranged from 32.0 to 33.0 ppt.

Standard deviations do not indicate a significant difference between surface and bottom mean salinity at monitoring stations although many of the probe salinity readings indicate that there were slight differences. During periods of moderate to heavy swell or high winds there appeared to be more uniform mixing of lagoon waters.

Probe salinity values were almost always lower than those obtained with the refractometer. This may mean that the internal temperature calibration of the probe is off, although it was calibrated before field use. Salinity values obtained on July 21 and August 4, 1979 are believed to more accurately reflect the station salinities. Salinities during these sampling periods ranged from 33.0 (stations 3 and 4, surface) to 35.0 ppt (station 9, surface and bottom). The mean salinity during those sampling periods was 33.8 ± 0.5 ppt.

Salinity values obtained in previous studies at Dublon (Amesbury et al., 1977) and Tol Islands (Clayshulte et al., 1978) also showed a wide variation with values ranging from 33.3 to 35.5 ppt.

Dissolved Oxygen

Dissoved oxygen concentrations in the water quality monitoring zone ranged from 4.40 mg/ℓ to 9.15 mg/ℓ (Table 9). The mean values for each site and depth show no significant difference at the 5 percent significance level based on the F distributions with means ranging from 5.75 mg/ℓ to 6.46 mg/ℓ (Table 9). The arithmetic mean of all oxygen readings in the water quality monitoring zone was 6.08 mg/ℓ (standard deviation 0.17 mg/ℓ). When the data are plotted on probability paper they yield a mean of 6.04 mg/ℓ (Fig. 6).

The dissolved oxygen concentrations, as can be seen from the low standard deviation, are usually quite close to the mean value. Oxygen saturation of seawater at the salinity and temperature measured in the water quality monitoring zone was 6.3 mg/ℓ. Therefore, the sampled seawater usually ranged from 94 to 99 percent saturation with an overall range from 70 to 129 percent saturation. Since all samples were collected during daylight hours the values would be expected to be near or at saturation levels.

Total Phosphorus

Total phosphorus concentrations ranged from 0.011 to 0.091 mg/ℓ at the eight water quality stations. At station 9, outside the water quality monitoring area, phosphorus ranged from 0.009 to 0.020 mg/ℓ. No significant differences exist between station means. Within stations, surface and bottom phosphorus levels were higher than those at 5 meter depths (Table 10).

The mean surface phosphorus concentration was 0.026 mg/ℓ. These values are low and characteristic of unpolluted water. Fig. 7 shows the plot of values obtained in a probability distribution. The geometric mean obtained from the graph is 0.020 mg/ℓ. The arithmetic mean concentration of phosphorus at Station 9, well outside of the water quality boundary, was 0.013 mg/ℓ.

Total Nitrogen

Total nitrogen concentrations in the study area ranged from below detection limits (0.01 mg/ℓ) to 0.54 mg/ℓ TKN. Results of samples analyzed within stations varied so much between this range that station mean values differ considerably (Table 11) due to the relatively small number of samples analyzed per station. When the values obtained are plotted on probability paper they yield a geometric mean of 0.038 mg/ℓ TKN which probably better represents the typical values to be obtained at a particular station (Fig. 8). Unlike the case of phosphorus, nitrogen concentrations at station 9 were not significantly lower than concentrations obtained in the water quality monitoring zone. Due to the fact that many samples contained TKN concentrations below the detection limit of the Standard Method used in analysis, an accurate nigrogen:phosporus ratio cannot be determined other than putting it below 4:1.

Heavy Metals

The results of the heavy metal analyses are presented in Table 12. Concentrations of zinc, copper, lead, and arsenic were below the detection limits of the techniques used. The detection limits are below the concentrations allowed by proposed TTPI water quality standards for these metals. For zinc, copper, and lead the concentrations were below 0.05 mg/ℓ. Arsenic concentrations were below 0.01 mg/ℓ.

Significant mercury presence was found in two samples (from stations 6 and 8) with all other samples containing less than 0.001 mg/ℓ. Station 8 had a relatively high mercury content of 0.0290 mg/ℓ. Only by means of additional analyses of the water in this area can be a possible explanation be found for this reading. It is possible that the sewage and waste water effluent (discharged less than 40 meters away) are mercury contaminated and responsible for the high reading obtained.

Previous Environmental Studies in Truk Lagoon

Water quality data collected in three previous environmental studies are presented in Table 13. The studies involved a survey of the effect of the Point Gabert sewage treatment plant outfall in the marine environment (Tsuda et al., 1975) and surveys of the possible effects of the proposed tuna fishery complexes on Dublon (Amesbury et al., 1977) and Tol Islands (Clayshulte et al., 1978).

The limited amount of water quality sampling data in these reports falls within the range of values obtained in this report.

Air Quality Monitoring

The results of the air particulate sampling indicate low levels of air particulates at both sites with geometric means of 17.1 $\mu g/m^3$ and 14.9 $\mu g/m^3$ for the weather station and quarry site respectively. Daily means of air particulates ranged from less than 10 $\mu g/m^3$ to over 41.5 $\mu g/m^3$ (Table 14). The high value of 41.5 $\mu g/m^3$ was obtained at the Metitiu Quarry site on a date when rock crushing activity and sieveing was taking place for most of the work day. The roads in Truk, since they are predominantly dirt or paved with dirt shoulders, produce dust in observable clouds during dry conditions. During the week of sampling, however, conditions were usually wet with daily showers.

Noise Quality Monitoring

Figures 9, 10, and 11 show the results of the 24-hour sound measurement surveys conducted at each of the selected areas. The data reveal a typical pattern of lower levels and narrow sound level ranges in late evening to early morning hours and higher levels and wider sound level ranges during daylight hours.

For each figure the plots of slow response are the mean values of the seven readings taken during each half hour period. The data reveal a quiet environment at the airport terminal except during a plane arrival and departure which occurs (as of July, 1978) only six times a week or about once a day. The plane arrival to departure time is usually less than one hour resulting in high noise levels occupying only from 4 to 5 percent of the daily time period at the airport terminal area.

Table 15 shows the noise levels produced by activities common to the airport terminal area. Plane operations dominate the higher noise levels (105 dB) as would be expected. Another significant noise contributor (80-90 dB) is construction equipment operation (i.e. bulldozer). This equipment is used in maintenance of the runway surface and shoulders and in land clearing activity between the airport runway and the sewage treatment plant. An OICC field office is located in the same area and traffic to and from this office, besides traffic to the airport terminal, weather station, and airport supporting facilities, contributes the next highest segment of background noise levels (approximately 60 dB) after construction equipment operation. Traffic on the road through Iras village and other village activities produce the next most significant noise contribution (approximately 50 dB).

Taken as a whole, background noise levels average 45 dB from 8:00 a.m. to 5:00 p.m. Night time noise levels average only some 3 decibels lower (42 dB). The minimum noise level was only 5 dB below this mean at 37 dB which indicates the quietness of this area. The Ldn was 48.7.

Metitiu Quarry site noise levels were higher than either the Airport Terminal or the Pou Bay Causeway. The Ldn of 58.1 dB was 10 decibels higher than the Ldn at the other two sites. The main cause of the higher average noise level is wind derived noise. The area is densely populated with coconut palms and other trees. Winds in excess of 10 Kts., such as those occurring at the monitoring site, create a high background noise level of 50 - 55 dB (Table 3). The average background noise level was 54 dB for both daylight and evening hours.

Elevated noise levels with greater ranges of values were observed during daylight working hours and were a result primarily of rock crushing work at the quarry. The highest half hour average noise level (68 dB) was a result of quarry rock crushing activity from 9:30 to 10:00 a.m.

Peak noise levels at the quarry sound measurement site were also a result of the rock crusher (89.5 dB). Heavy traffic on the road fronting the quarry was also a significant noise contributor (83.0 dB). Other events which produced decibel readings close to or above 80 decibels were rain showers and associated wind noise (82 dB), general quarry work excluding rock crushing (81 dB), and landings at the airport (80 dB).

The 80 dB reading for the jet landing may be lower than a reading taken at the station when the jet takes off in the easterly direction. A reading of this event was not obtained. Table 15 also presents other lessor contributors to peak noise events. Wind gusts through the palm fronds and pig pen noises (both 76.5 dB) are common events at the Metitiu Quarry measurement site. Light traffic (one vehicle of apparent typical loudness) produced decibel readings of 57 dB. Engine noise from the rock crusher crane produced a constant 55.5 decibel noise level when operating.

The noise levels at Pou Bay were affected during the study by inclement weather during the early morning hours. Both high winds (>25 Kts.) and surf caused elevated noise readings (Fig. 11) of over 50 decibels. The Ldn was 48.1, least of all three stations studied. During practically windless and surfless conditions during the early evening hours the average noise level dropped to just below 40 decibels.

Peak noises during the day were attributed to airliner take-off (87.7 dB) and activities occurring on the causeway (Table 5). Morning and late afternoon shuttle boats (outboard motors) from Fano Island produced readings of 84.5 dB. Net fishermen, fishing off the boat docking area within 100 feet of the sound level meter, produced readings of 84 decibels. During the period of inclement weather rain and surf noise registered a high of 82.7 decibels. A commercial airliner fly by on approach to the airport produced a high decibel reading of 71. The remaining peak noises were derived from vehicular traffic along the road through Tunuk village (64.5 dB).

One unusual noise factor was observed at the Pou Bay noise measurement site. Large peak readings of 80-90 decibels were recorded at night when apparently no sound was heard. After careful watching and listening the readings were attributed to either insect noises from insects flying near or in close vicinity to the microphone or to crustacean noises during night time feeding activity. When an octave band analyses of the pops and cracks heard from crustaceans was undertaken, the highest frequency band of 31,500 predominated.

High frequency octave bands of 16,000 and 8,000 were noted in the band analysis of these "sounds". As mentioned, these insect or crustacean "sounds" were usually unnoticed by the person monitoring the sound level meter and are mentioned only so that future workers will be aware of this field condition.

RECOMMENDED TURBIDITY STANDARD

Results show that turbidity in the water quality zone is similar for areas running from the northeast end of the airport runway to the southwest end of Pou Bay. Values in excess of 1 NTU are extremely rare (1.3%). The data were collected over 1/4 of the annual cycle and seasonal changes in current direction or speed could produce lower or higher turbidities.

Based on the data collected, a turbidity limit of 2 NTU is justifiable and responsible if waters beyond the water quality boundary are to be kept free of substantial construction or dredge produced turbidity. Based on the probability distribution (Fig. 4), a 2 NTU turbidity reading should occur only once in every 1,493 samplings. A total of only 288 turbidity samples are expected to be taken at the eight water sites during the part B phase of the monitoring program.

A turbidity limit of 2 NTU also will be close to the proposed turbidity standard for the proposed Trust Territory of the Pacific Islands (TTPI) Water Quality Standards. The proposed turbidity standard requires that natural turbidities are not affected by more than 10% in Class A waters (recreational, aesthetic enjoyment, support and propogation of aquatic life) and no more than 20% in Class B waters (areas immediately adjacent to boat docking facilities). If natural turbidity reaches 1.5 NTU (the highest turbidity measured in the study) 20% or 10% of this value added to 1.5 will produce a figure close to but below 2 NTU. According to the executive officer of the Trust Territory Environmental Protection Board (TTEB), the proposed TTPI Water Quality Standards should become effective within the next few months.

It is recommended that upon finding a turbidity reading in excess of 2 NTU, subsequent (hourly, or more frequent) readings be taken for two additional hours to insure that the violation is due to sustained construction operations and not due to freak conditions or events. Also, additional turbidity readings should be undertaken in other areas outside the mixing zone that are likely to be affected by the violation so that the extent of the violation can be determined.

The TTEB should also conduct daily visual inspections of the dredging and construction operations for evidence of sizeable silt plumes which might produce violations of the turbidity standard and other TTPI water quality standards.

SUMMARY

Eight water quality monitoring stations were selected for biweekly water quality monitoring over a three month period (May 21, 1978 to August 4, 1978). The stations were established beyond the water quality boundary and placed to cover all work areas included in the airport construction project.

Two air quality (airborne particulates) stations were established for continuous one week sampling in two areas likely to be affected by airport construction activity.

Three noise monitoring stations were established for continuous 24-hour sampling in three areas likely to be affected by construction activity.

Results of the water quality monitoring indicate that nutrients (nitrogen and phosphorus) and dissolved oxygen fall well within the proposed TTPI Water Quality Standards for either Class A or B waters under which these waters are to be classified. The geometric mean concentrations of phosphorus, nitrogen, and dissolved oxygen at the water quality monitoring stations were 0.020 mg/ℓ, .038 mg/ℓ, and 6.04 mg/ℓ respectively. Based on the collected data, a turbidity limit of 2 NTU is recommended for the water quality zone beyond the water quality boundary.

Heavy metal analyses of water near the sewage treatment plant outfall (station 8) indicate possible mercury contamination (0.029 mg/ℓ). Additional sampling for mercury in this area and of sewage effluent is recommended.

Air quality sampling with high volume air samplers for one week obtained geometric mean air particulate concentrations of 17.1 $\mu g/m^3$ at the weather station and 14.9 $\mu g/m^3$ across from the Metitiu Quarry.

Sound level pressure readings of background noise obtained Ldn values of 48.7 dB(A) at the Weather Station, 58.1 dB(A) across from the Metitiu Quarry, and 48.1 dB(A) at the Pou Bay Causeway. Peak noise levels at the Weather Station (105 dBA) and Pou Bay Causeway (87 dBA) were a result of commercial airliner landings or taxiing at the airport. The rock crusher produced the loudest sound pressure level readings at the quarry station (89 dBA).

ACKNOWLEDGMENTS

We acknowledge Mr. Nachsa Siren, Executive Officer of the Trust Territory Environmental Protection Board, for providing logistic support and information. We are grateful to Mr. Mitaro Danis, District Administrator of Truk, for arranging boat usage and other logistic support in Truk. We thank Mr. Sikaret Lorin, Chief District Sanitarian, for providing personnel support and transportation. We thank Mr. Sanphy P. Williams, Department of Health and Sanitation, for providing laboratory space and storage of monitoring equipment. Mr. Joshua Simon, Department of Health and Sanitation, provided invaluable field assistance. We thank Mr. Dan Patterson, Department of Land Management Mapping Section, for providing maps of the study area and Mr. Richard Howell, Department of Marine Resources, for providing reefer space. Special thanks goes to Mr. Kenchy Kincho, Boat Manager of the Department of Public Works Boat Pool, and Boat Pool personnel for boat usage. We are indebted to Mr. Rudolpho Pontemayor, environmental engineer for the Guam Environmental

Protection Agency, for providing assistance and equipment in the air and noise monitoring. We are grateful to Mr. Lasaro R. Maipi and Mr. Bernardo M. Aten, NOAA Weather Station on Moen, Truk, for providing space for air and noise monitoring and for meteorological data. We thank Herta and Yosiwo of Iras village for providing space on their property for air and noise monitoring. We extend our special thanks to our secretary, Mrs. Evelyn Paulino, for typing the manuscript.

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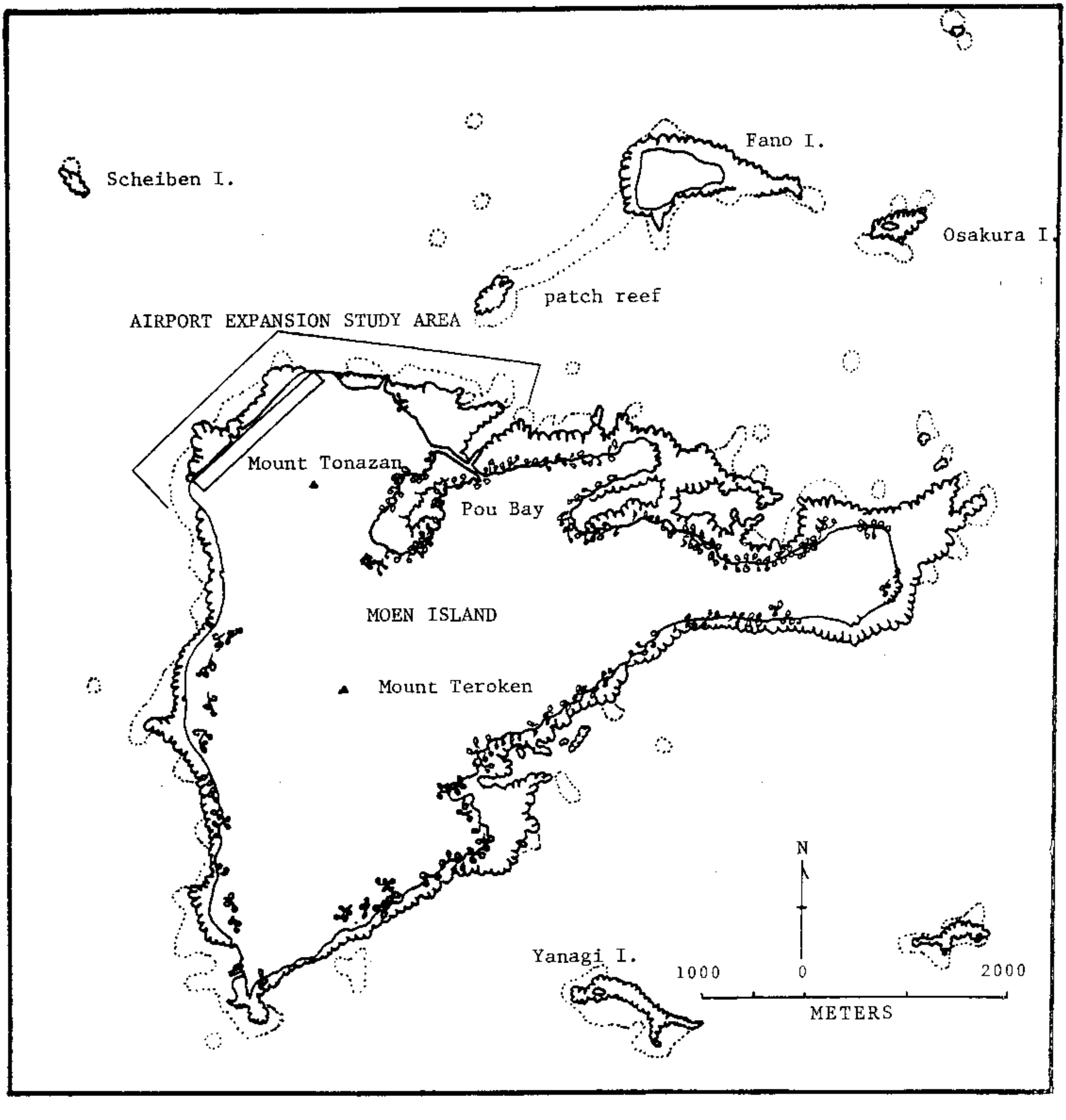

Fig. 1. Airport expansion study area on Moen Island, Truk. The small leaf-like structures indicate mangrove swamp. The dotted lines are patch reefs and/or shallow areas.

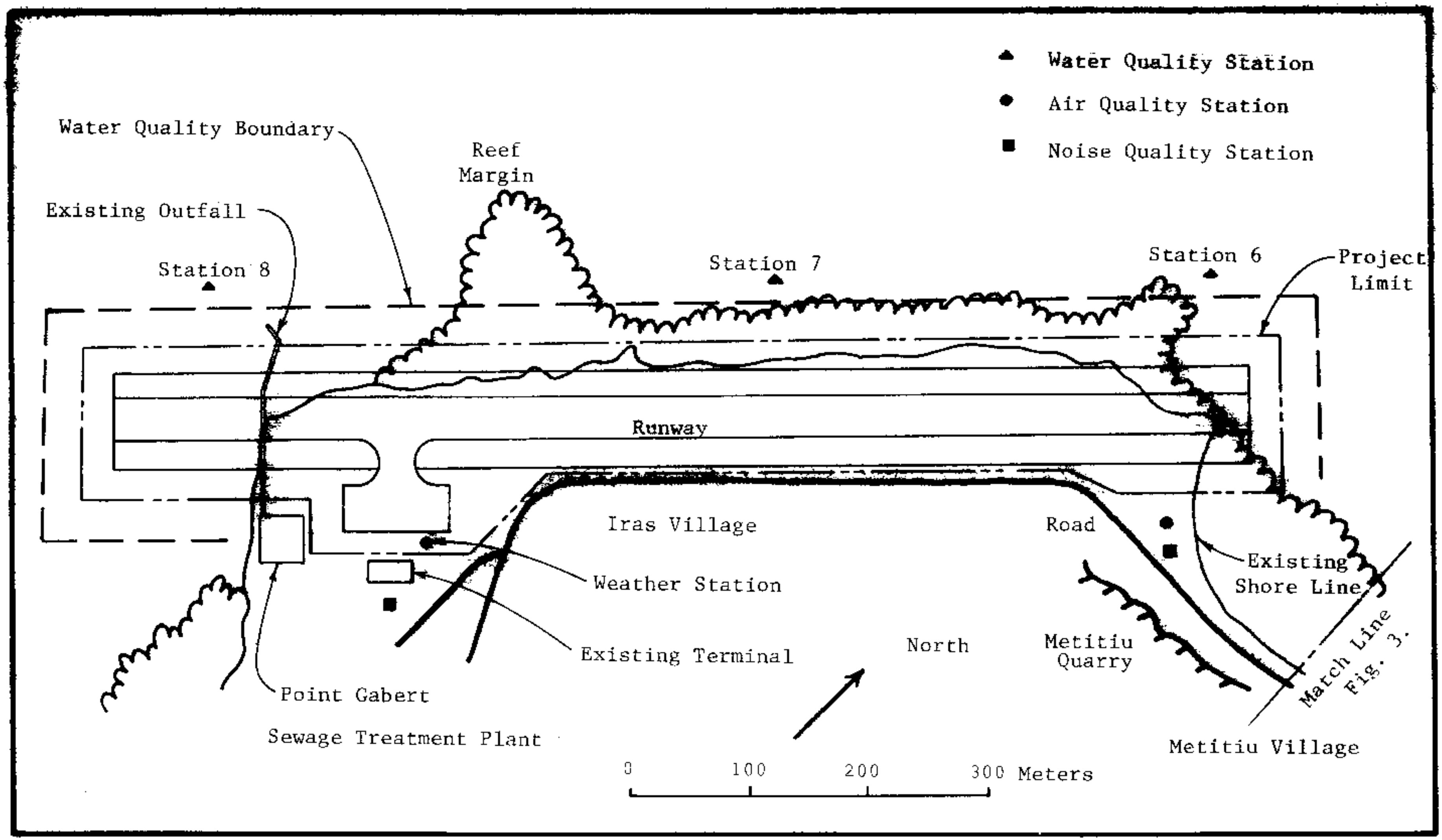

Fig. 2. Locations of air, noise, and water quality monitoring stations in vicinity of airport construction area.

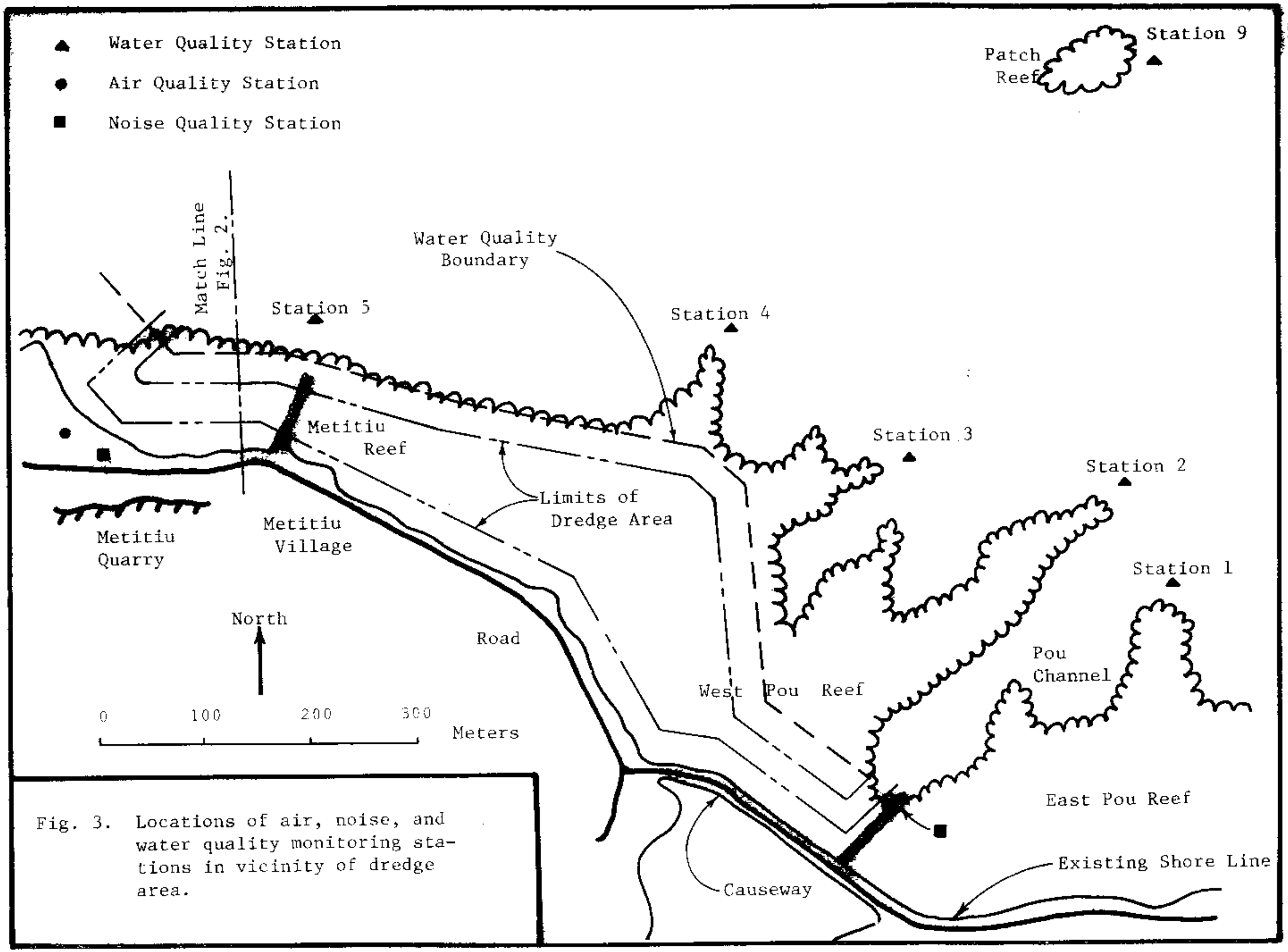

Fig. 3. Locations of air, noise, and water quality monitoring stations in vicinity of dredge area.

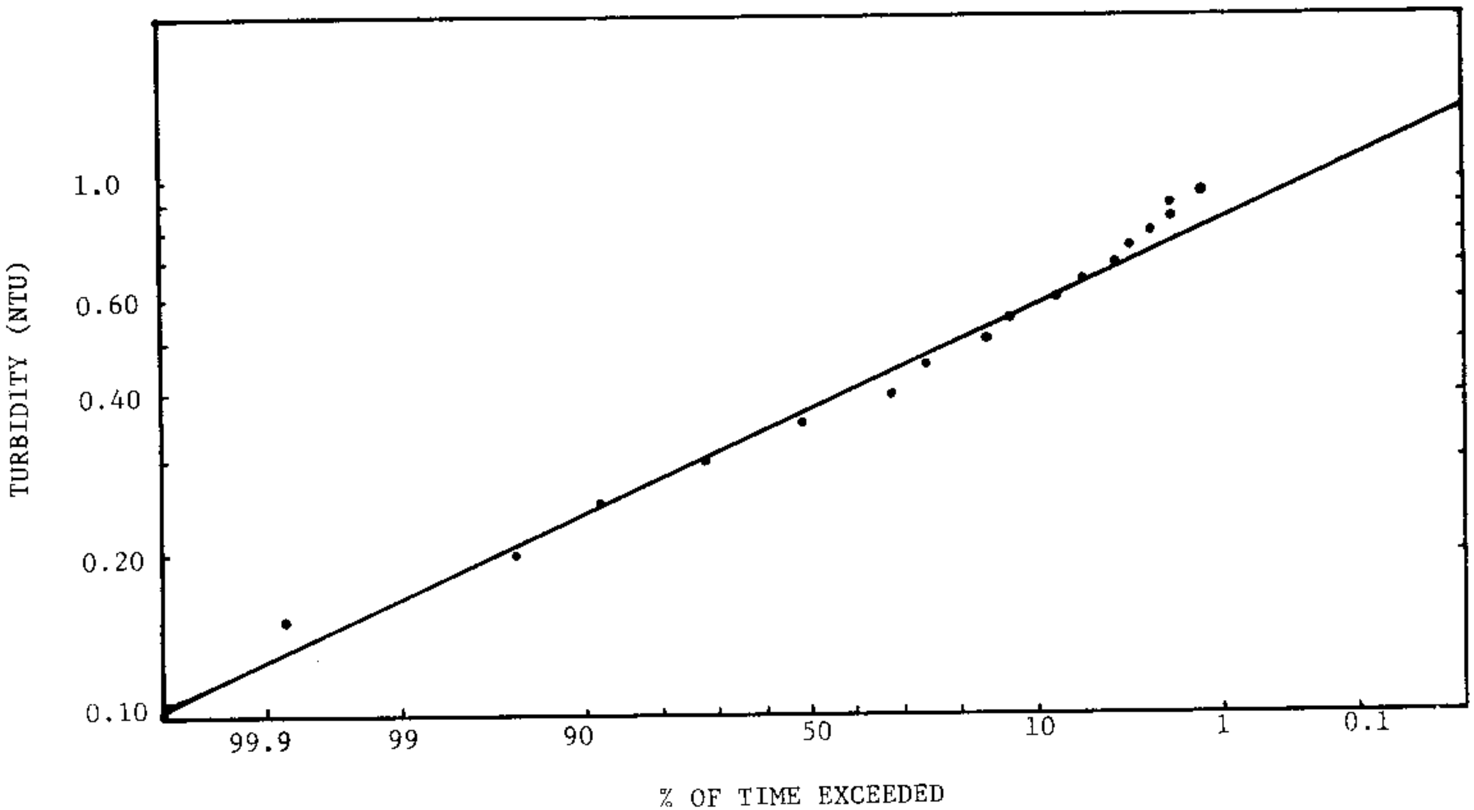

Fig. 4. Probability distribution of turbidity measurements at the eight water quality stations. The geometric mean turbidity is 0.37 NTU.

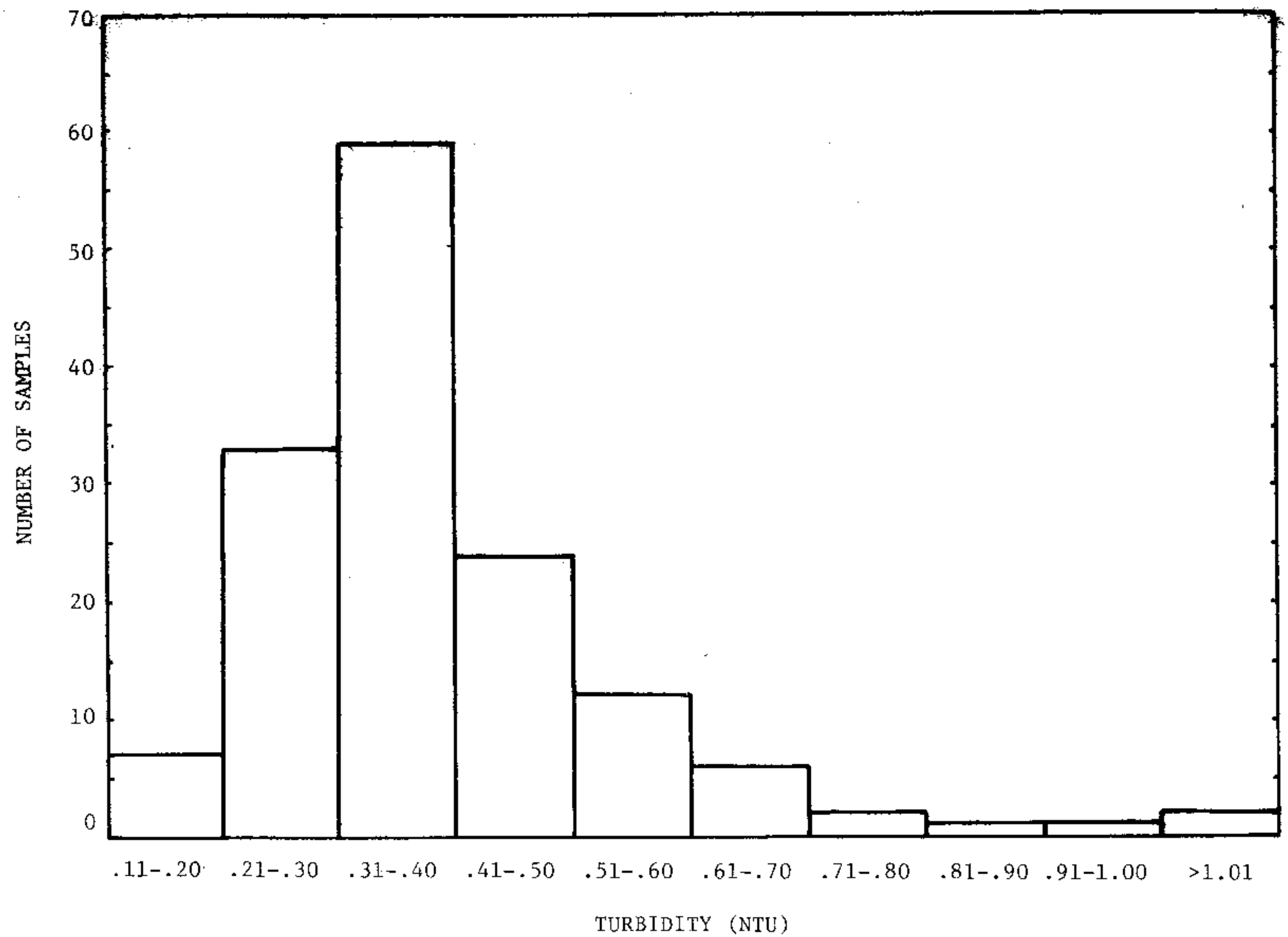

Fig. 5. Bar graph of turbidity measurements

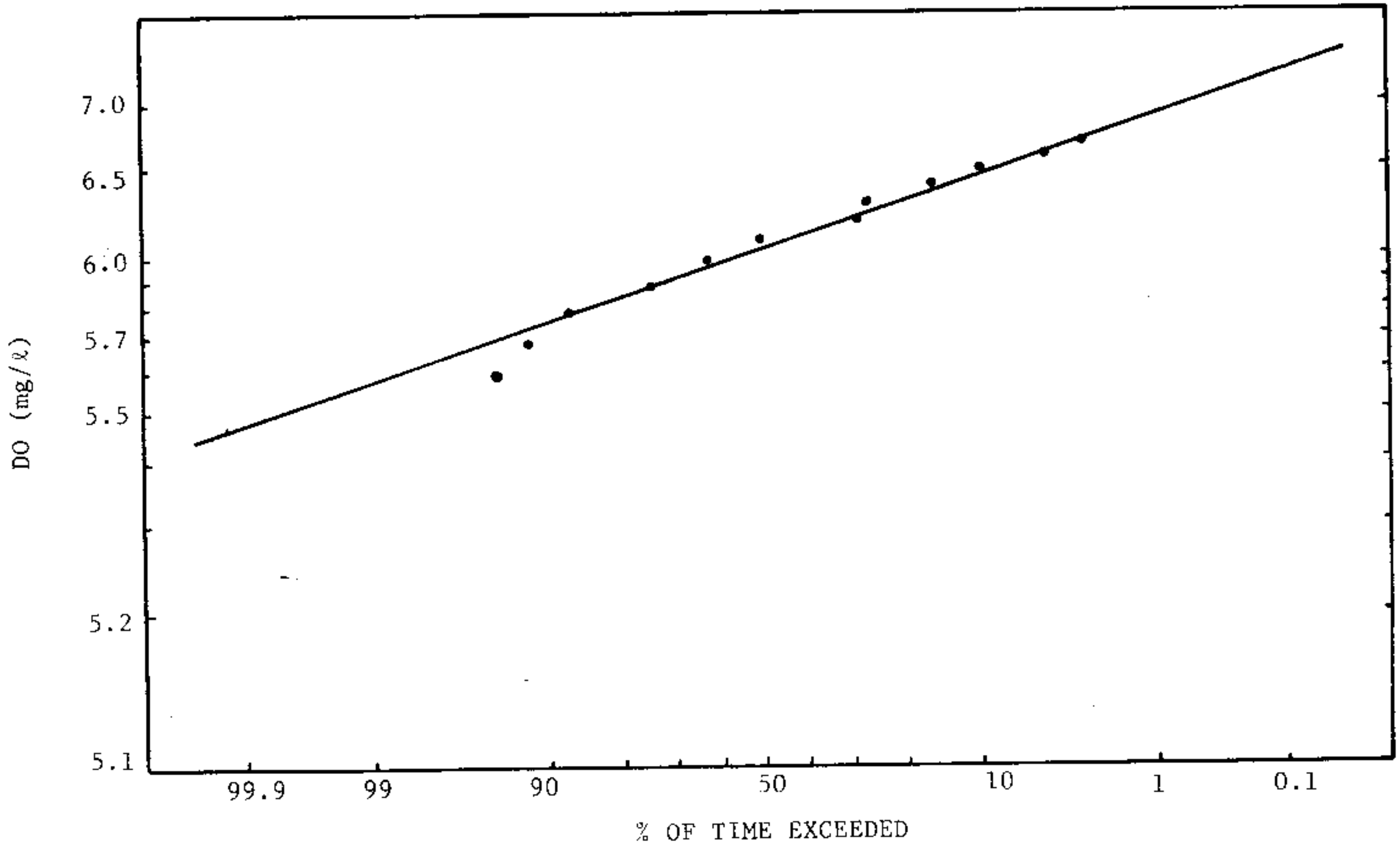

Fig. 6. Probability distribution of dissolved oxygen measurements at the eight water quality monitoring stations. All measurements were made during daylight hours. The geometric mean dissolved oxygen concentration is 6.04 mg/ℓ.

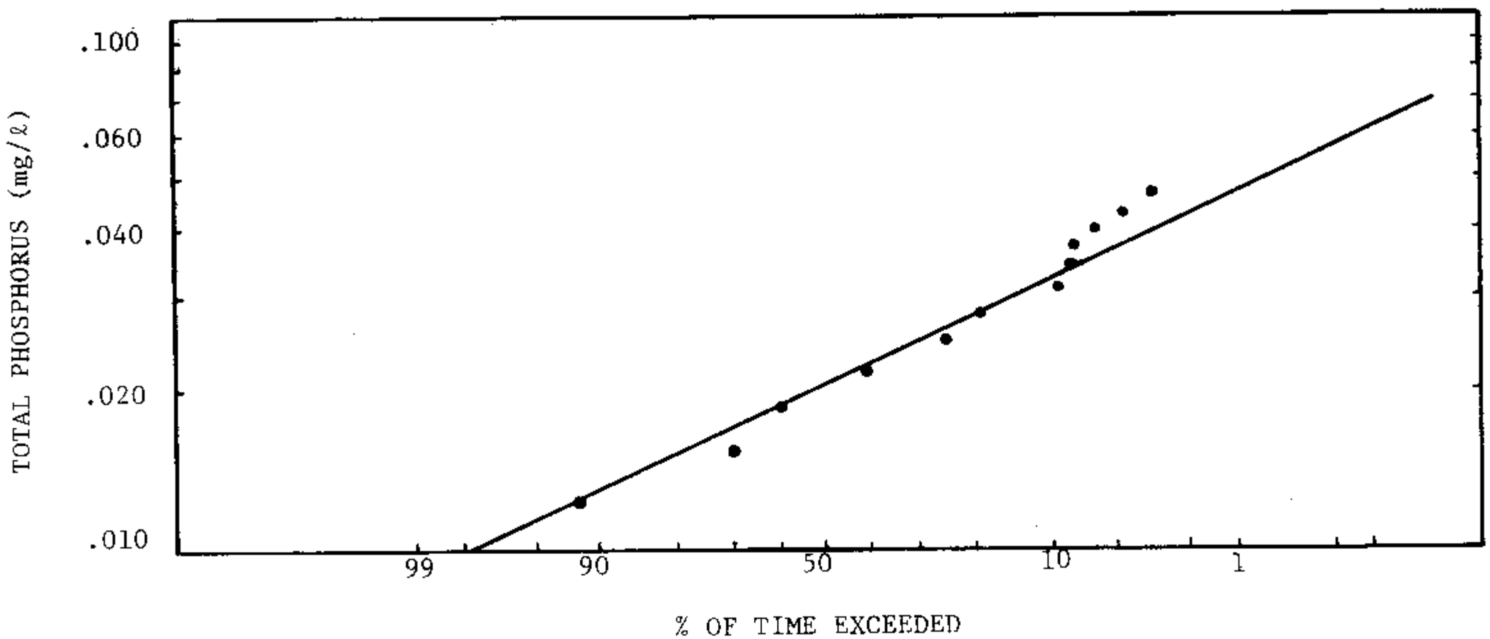

Fig. 7. Probability distribution of total phosphorus concentrations from the eight water quality monitoring stations. The geometric mean concentration is .020 mg/ℓ.

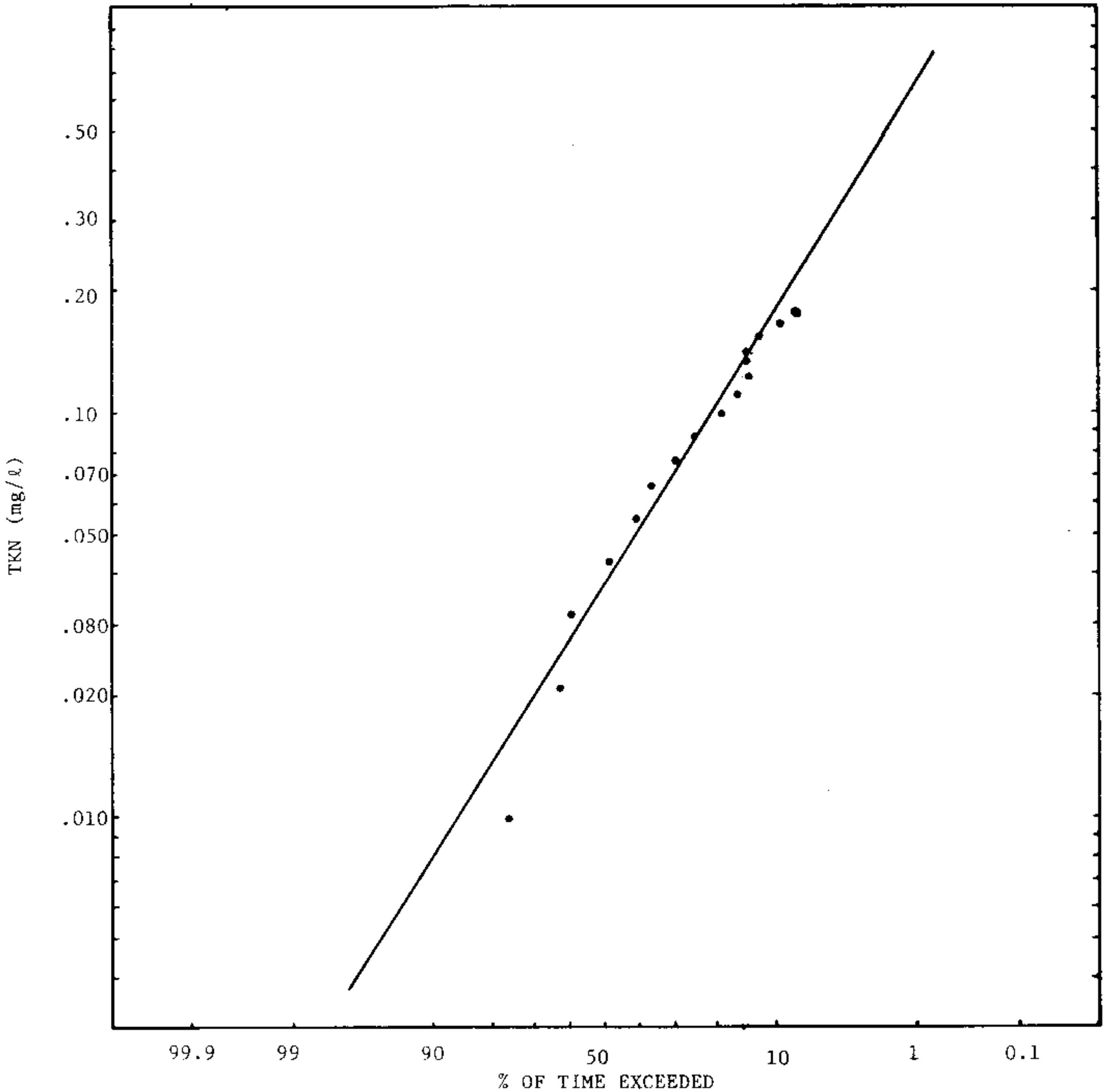

Fig. 8. Probability distribution of total Kjeldahl nitrogen concentrations from all eight water quality monitoring stations. The geometric mean concentration is .038 mg/ℓ.

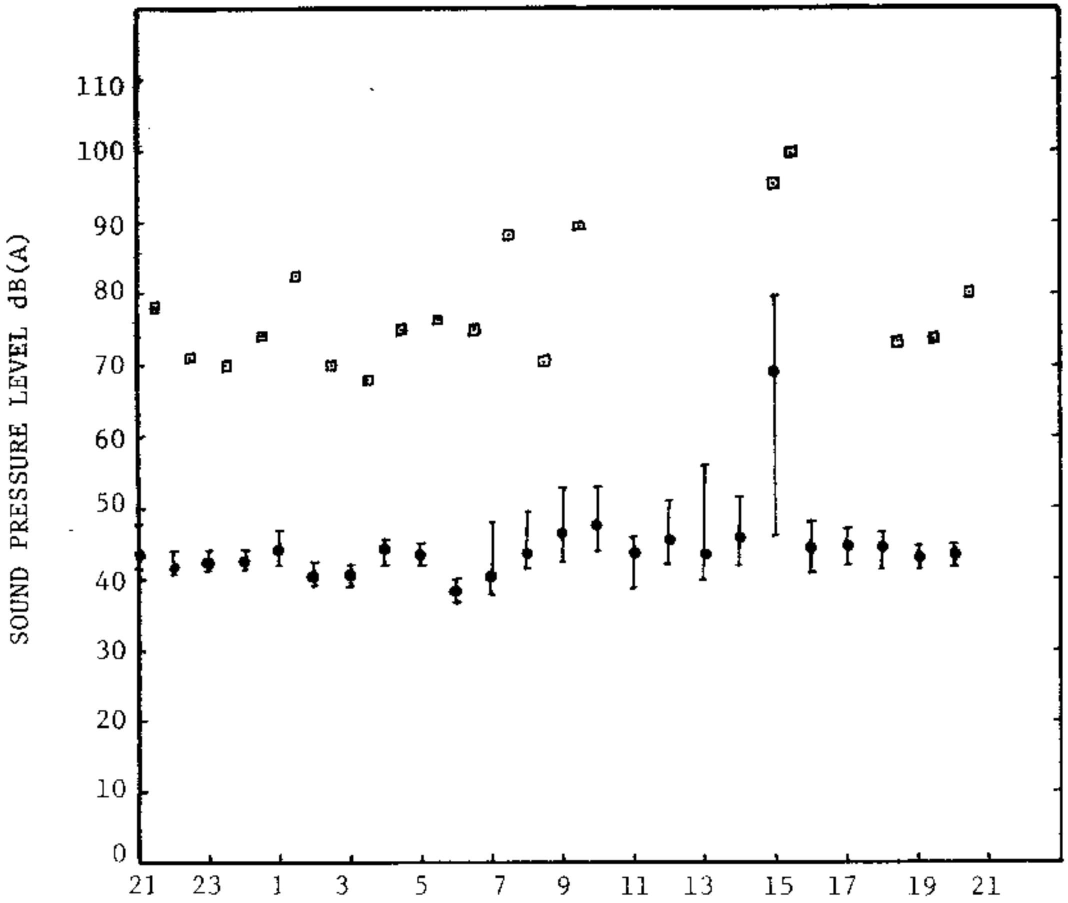

Fig. 9. Half hour mean sound pressure levels (●) and half hour peak noise levels (◘) at noise station 1, on the grounds of the Truk weather station. The background sound pressure readings (taken every five minutes) were A weighted with the sound level pressure meter on slow response.

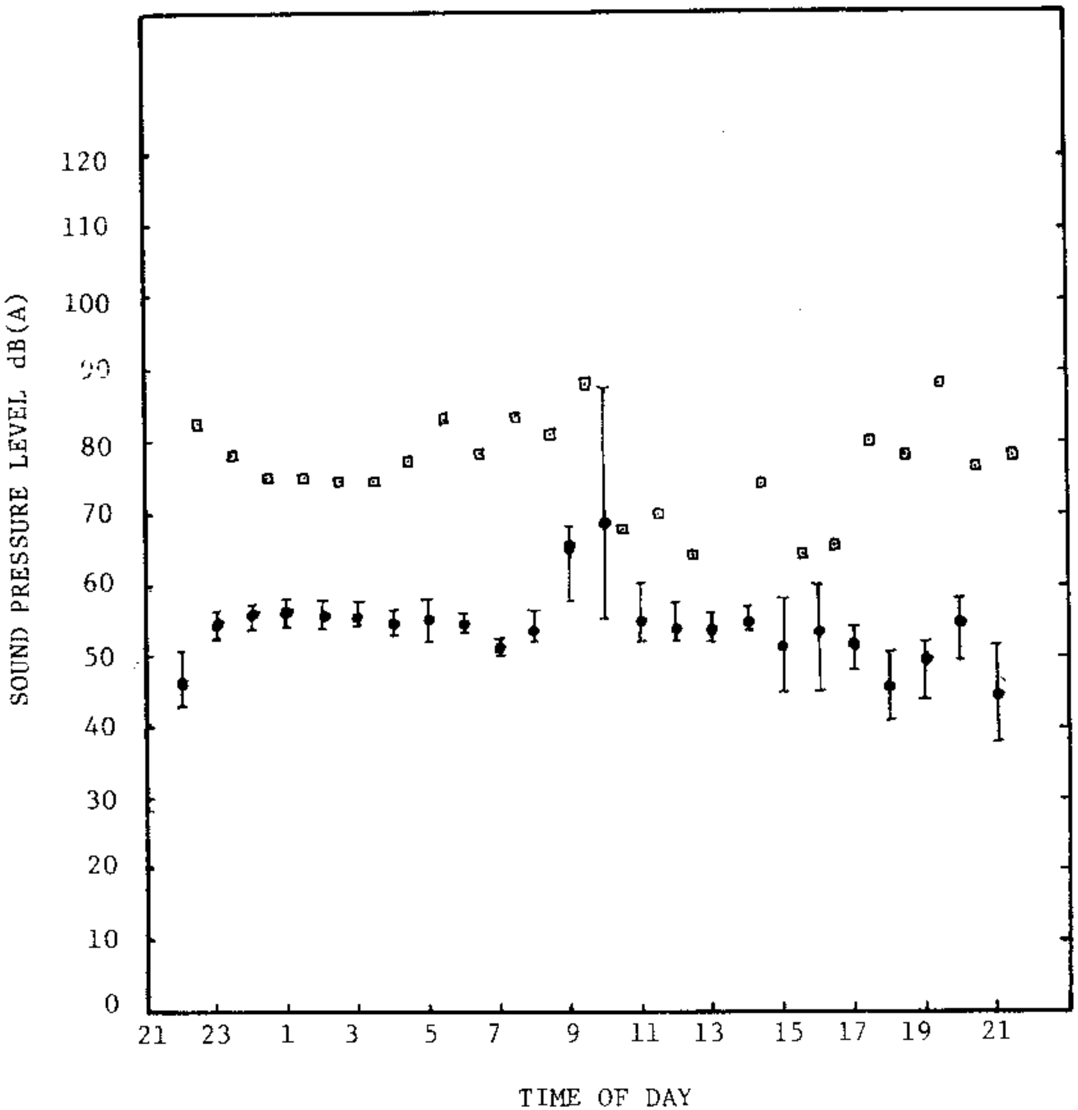

Fig.10. Half hour mean sound pressure levels (●) and half hour peak noise levels (□) at noise station 2, across from the Metitiu Quarry. The background sound pressure readings (taken every five minutes) were A weighted with the sound level pressure meter on slow response.

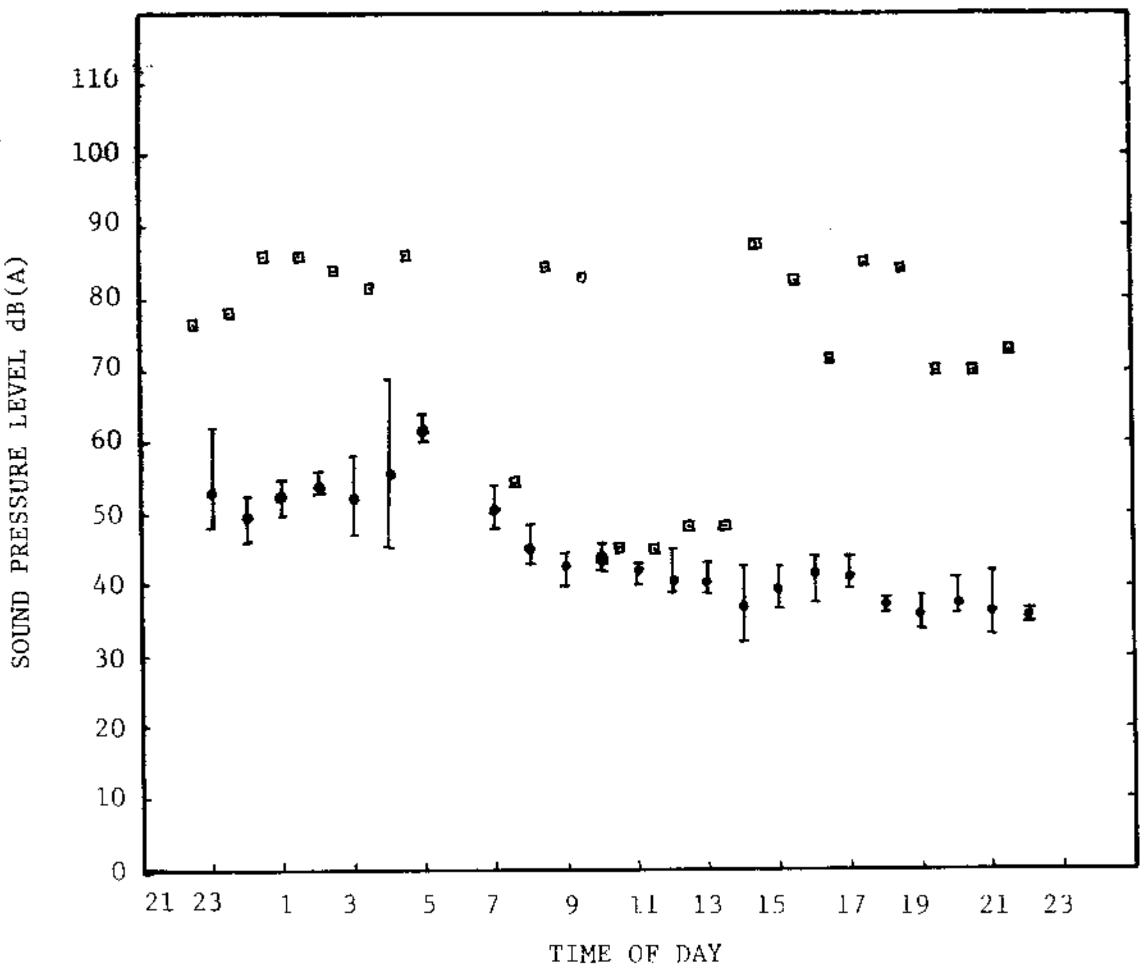

Fig. 11. Half hour mean sound pressure levels (●) and half hour peak noise levels (□) at noise station 3, off Pou Bay Causeway. The background sound pressure readings (taken every five minutes) were A weighted with the sound level pressure meter on slow response.

Table 1. Physical and chemical parameters and methods used in analyses for part A water quality monitoring. All standard methods of analyses were performed according to the fourteenth edition (1975).

PARAMETER	METHOD	SOURCE
CHEMICAL		
Dissolved Oxygen (DO)	Azide Modified Winkler Titration	Standard Methods
Total Phosphorus (TP)	Persulfate Digestion/Ascorbic Acid Reduction	Standard Methods
Total Kjeldahl Nitrogen (TKN)	Nesslerization	Standard Methods
Lead	Atomic Absorption Spectrophotometry	Standard Methods
Mercury	"	Standard Methods
Zinc	"	Standard Methods
Copper	"	Standard Methods
Arsenic	"	Standard Methods
PHYSICAL		
Turbidity	Nephelometer (NTU)	Standard Methods
Secchi Turbidity	Secchi Disk	
Temperature	Mercury Thermometer, Salinometer Probe	Standard Methods
pH	pH Meter (combination electrode)	Standard Methods
Salinity (Probe)	YSI Salinity Probe	
Salinity (Refractometer)	Optical Refractometer	

Table 2. Average wind direction and speed, total sunshine, total percipitation and Newacho Harbor water temperature for May 17 - June 2, 1978. The wind ranges are read in a clockwise direction.

	WIND				SUNSHINE	RAIN	TEMPERATURE
DATE	COMPASS DIRECTIONS	RANGE	SPEED (kts)	RANGE	TOTAL 24 Hr. (min.)	TOTAL 24 Hr. (w)	HARBOR WATER (°C)
5/17/78	08.6 ± 05	29 - 10	10.8 ± 2.3	07 - 14	58	0.10	28.6
5/18/78	08.3 ± 03	04 - 13	8.0 ± 3.5	04 - 14	48	0.83	28.6
5/19/78	15 ± 08	01 - 31	8.9 ± 2.9	05 - 15	0	1.47	----
5/20/78	07.6 ± 05	00 - 18	8.0 ± 2.9	03 - 14	90	0.03	28.6
5/21/78	10.3 ± 05	30 - 14	6.9 ± 2.1	03 - 10	288	Tr.	----
5/22/78	9.5 ± 04	00 - 16	6.5 ± 2.7	00 - 10	80	0.76	----
5/23/78	14 ± 04	00 - 23	6.2 ± 3.3	00 - 11	168	0.19	28.6
5/24/78	9.1 ± 05	01 - 19	5.3 ± 2.5	00 - 10	58	1.35	28.6
5/25/78	12.6 ± 09	21 - 13	7.2 ± 2.7	03 - 14	0	0.01	28.3
5/30/78	14.2 ± 06 *	07 - 26	2.5 ± 2.2	00 - 06	243	0.13	29.4
5/31/78	6.9 ± 02	04 - 10	7.5 ± 2.6	05 - 12	633	0.17	29.2
6/ 1/78	8.1 ± 03	05 - 16	7.3 ± 1.9	05 - 12	450	0.01	29.1
6/ 2/78	9.9 ± 04	05 - 21	6.5 ± 2.5	03 - 12	350	0.22	29.0

* 8 periods with dead wind readings.

Table 3. Average wind direction and speed, air temperature, barometric pressure, total percipitation and total sunshine for June 20 – August 4, 1978. Wind ranges are read in a clockwise direction.

	WIND				AIR TEMPERATURE		BAROMETRIC PRESSURE		RAIN	SUNSHINE
DATE	COMPASS DIRECTION	RANGE	SPEED (kts)	RANGE	$\bar{Y}$ (°C)	RANGE	PRESSURE (in Hg.)	RANGE	TOTAL 24 hr. (in.)	TOTAL 24 hr. (min.)
6/20/78	12 ± 04 *	03 - 15	7.3 ± 2.7	03 - 12	27.9	27.0 - 29.3	29.832	.790 - .845	0.03	---
6/21/78	8.6 ± 03	05 - 14	8.5 ± 4.0	03 - 18	28.4	26.7 - 30.4	29.805	.750 - .845	0.11	---
6/22/78	7.7 ± 03	04 - 16	9.0 ± 3.7	00 - 17	28.1	25.4 - 30.3	29.770	.730 - .815	0.51	---
6/23/78	11 ± 05	01 - 25	6.3 ± 3.0	00 - 12	26.2	25.3 - 27.2	29.804	.740 - .845	0.44	---
6/24/78	19.3 ± 09	05 - 28	6.7 ± 2.6	03 - 13	27.0	24.7 - 30.1	29.822	.790 - .875	0.53	---
6/25/78	18.3 ± 14	29 - 17	8.3 ± 2.7	03 - 13	27.4	25.1 - 30.0	29.833	.785 - .875	---	---
6/26/78	6.8 ± 03	03 - 13	7.8 ± 2.4	04 - 13	28.4	26.7 - 30.4	29.788	.770 - .820	---	---
6/27/78	10.7 ± 03	07 - 15	5.8 ± 2.4	00 - 11	28.4	26.1 - 30.7	29.775	.735 - .805	---	---
6/28/78	.5 ± 04 *	01 - 13	6.3 ± 1.5	04 - 08	28.2	25.9 - 29.4	29.786	.770 - .800	---	---
7/ 7/78	7.8 ± 04	04 - 14	5.9 ± 2.0	03 - 09	25.0	23.8 - 26.2	29.816	.765 - .860	Tr.	408
7/21/78	22.8 ± 06	21 - 15	6.3 ± 2.3	03 - 11	27.6	24.7 - 30.5	29.772	.730 - .805	0.53	6
8/4/78	9.3 ± 04	04 - 17	7.9 ± 2.5	04 - 12	27.2	24.0 - 29.0	29.795	.750 - .840	1.86	6

* Calculations are based on partial data.

Table 4. Turbidity measurements (NTU) of surface and bottom waters at water quality monitoring stations. The tidal state during sampling is presented in the column to the right of the sampling date.

STATION	DEPTH (m)	MAY 20	TIDE	MAY 24	TIDE	MAY 26	TIDE	MAY 30	TIDE	JUNE 1	TIDE	JUNE 1	TIDE
Station 1	surface	0.31	Rise					0.18	Fall	0.20	Rise		
	bottom	0.94		0.28	Fall	0.47	Fall	0.28		0.18		0.30	Fall
Station 2	surface			0.15		0.24							
	bottom	1.3	Rise	0.26		0.40		0.24		0.18		0.44	
Station 3	surface							0.23		0.36			
	bottom	1.5	Slack	0.37	Rise	0.38		0.35		0.64		0.40	
Station 4	surface							0.28		0.34			
	bottom	0.68	Fall	0.39		0.38		0.24		0.34	Rise	0.15	
Station 5	surface							0.22		0.33	Slack		
	bottom	0.40		0.29		0.37		0.30		0.24		0.38	
Station 6	surface							0.27		0.32			
	bottom	0.34	Fall	0.42		0.34		0.27		0.35		0.24	
Station 7	surface	0.46	Slack					0.33		0.30			
	bottom	0.39		0.39		0.42	Fall	0.53		0.38	Slack	0.22	
Station 8	surface	0.36	Rise					0.33		0.48	Fall		
	bottom	0.28		0.42	Rise	0.28	Slack	0.48	Fall	0.68			

Table 4. (Cont.)

STATION	DEPTH (m)	JUNE 2	TIDE	JUNE 26	TIDE	JULY 7	TIDE	JULY 21	TIDE	AUGUST 4	TIDE	$\bar{y}$	s	N
Station 1	surface	0.28	Rise	0.47	Fall	0.33	Rise	0.33	Rise	0.34	Rise	0.38	0.18	19
	bottom	0.56		0.45		0.38		0.33		0.58				
Station 2	surface	0.46		0.27		0.38		0.43		0.28		0.40	0.26	18
	bottom	0.56		0.38		0.29	Rise	0.38	Rise	0.64	Rise			
Station 3	surface	0.35		0.59		0.66	Slack	0.50	Slack	0.46	Slack	0.50	0.28	18
	bottom	0.46		0.40		0.34		0.37		0.58				
Station 4	surface	0.39		0.46		0.75		0.48		0.42		0.41	0.15	18
	bottom	0.40	Rise	0.28		0.54	Slack	0.44	Slack					
Station 5	surface	0.28	Slack	0.33		0.84	Fall	0.52	Fall	0.36	Fall	0.36	0.14	18
	bottom	0.32		0.32		0.35		0.27		0.36				
Station 6	surface	0.38		0.44		0.33		0.47		0.35		0.34	0.06	18
	bottom	0.34	Slack	0.25		0.36		0.32		0.38				
Station 7	surface	0.28	Fall	0.26		0.54		0.53		0.42		0.39	0.11	19
	bottom	0.28		0.33		0.57		0.24		0.47				
Station 8	surface	0.27		0.42		0.32		0.38		0.64		0.43	0.15	19
	bottom	0.38	Fall	0.38	Fall	0.57	Fall	0.35	Fall	0.78	Fall			
Station 9	surface			0.27	Slack			0.23		0.22	Rise	0.24	0.04	8
	bottom	0.28	Rise	0.18		0.30	Rise	0.20	Rise	0.24				

Grand Mean Turbidity (Mean of the Means) is 0.40 $\pm$ 0.16 NTU.

Table 5. Comparison of mean turbidity readings between rising tide, slack tide, and falling tide. Readings taken 20 minutes before and after tidal changes are considered slack tide readings.

	RISING TIDE READINGS			SLACK TIDE READINGS			FALLING TIDE READINGS		
STATION	N	$\bar{y}$	s	N	$\bar{x}$	s	N	$\bar{x}$	s
#1	10	0.39	0.22	0	----	----	9	0.36	0.13
#2	11	0.47	0.31	0	----	----	7	0.31	0.10
#3	5	0.44	0.12	7	0.63	0.40	6	0.39	0.12
#4	5	0.37	0.03	6	0.50	0.14	7	0.35	0.17
#5	1 *	0.29	----	4	0.29	0.04	13	0.39	0.15
#6	1 *	0.42	----	4	0.35	0.03	13	0.34	0.07
#7	1 *	0.39	----	4	0.38	0.07	14	0.39	0.12
#8	3	0.35	0.07	1 *	0.28	----	15	0.45	0.16
#9	6	0.25	0.04	2 *	0.23	----	0	----	----
	N	$\bar{y}$	$s\bar{y}$	N	$\bar{y}$	$s\bar{y}$	N	$\bar{y}$	$s\bar{y}$
ALL STATIONS	6	0.38	0.08	5	0.43	0.14	8	0.37	0.04

* Not used in computations of grand means.

Table 6. Temperature measurements at the eight water quality monitoring stations and control station. The mean temperature, standard deviation and number of samples per station is shown in the columns to the right. The grand mean is the mean of all temperatures recorded at the water quality monitoring stations.

STATION	DEPTH	MAY 20	JUNE 1	JUNE 1	JUNE 26	JULY 7	JULY 21	AUGUST 4	$\bar{y}$	s	N
Station 1	surface	28.8	29.2	29.5	29.7	30.1	29.1	29.9	29.4	0.4	14
	5m			29.3							
	bottom	28.7	29.4		29.5	29.5	29.0	29.7			
Station 2	surface	28.9	29.4	29.6	29.7	30.1	29.2	29.8	29.4	0.4	14
	5m			29.2							
	bottom	28.8	29.1		29.4	29.4	29.1	29.7			
Station 3	surface	28.9	29.4	29.6	30.5	29.9	29.1	30.1	29.5	0.5	14
	5m			29.2							
	bottom	28.8	29.2		29.4	29.4	29.2	29.8			
Station 4	surface	28.8	29.4	29.4	29.9	29.9	29.0	29.8	29.4	0.4	14
	5m			29.3							
	bottom	28.9	29.3		29.4	29.5	29.3	29.8			
Station 5	surface	29.8	29.6	29.6	29.8	29.7	29.0	30.0	29.5	0.4	14
	5m			29.2							
	bottom	28.8	29.3		29.4	29.6	29.0	29.9			
Station 6	surface	29.5	29.4	29.7	29.7	28.8	29.1	29.8	29.5	0.3	14
	5m			29.2							
	bottom	28.9	29.2		29.4	29.7	29.2	29.8			
Station 7	surface	28.6	29.3	29.4	29.5	29.8	29.2	29.7	29.3	0.5	14
	5m			29.2							
	bottom	28.7	29.2		29.5	29.7	29.7	29.1	29.7		
Station 8	surface	28.7	29.3	29.4	29.5	29.8	29.1	29.8	29.3	0.4	14
	5m			29.2							
	bottom	28.6	29.4		29.3	29.7	29.0	29.8			
Station 9	surface					29.8	29.1	29.9			
	bottom					29.6	29.1	29.9			

Grand Mean = 29.4 ± 0.4

Table 8. Salinity values in parts per thousand (ppt) for surface and bottom waters at phase A monitoring stations. Mean values are computed using salinometer probe readings obtained prior to June 26 and optical refractometer readings for June 26 - August 4.

		MAY 20	JUNE 2	JUNE 26		JULY 7		JULY 21	AUGUST 4				
STATION	AVE. DEPTH	PROBE	PROBE	PROBE	OPTICAL	PROBE	OPTICAL	OPTICAL	PROBE	OPTICAL	$\bar{y}$	s	N
#1 surface		32.8	31.0	33.5	35.2	33.4	35.0	33.9	33.5	34.4	33.7	1.3	6
#1 bottom	7.8m	32.5	30.0	33.0	35.0	33.4	35.0	34.4	33.5	34.4	33.6	2.0	6
#2 surface		34.5	31.8	33.8	34.4	33.5	34.4	33.9	33.3	34.4	33.9	1.0	6
#2 bottom	6.7m	34.2	31.8	33.5	35.0	33.0	34.4	34.4	33.3	34.4	34.0	1.1	6
#3 surface		33.8	31.8	33.8	35.3	33.5	34.4	33.9	33.0	33.3	33.8	1.2	6
#3 bottom	7.6m	32.8	31.8	33.5	35.5	33.0	34.4	33.9	33.5	34.4	33.8	1.3	6
#4 surface		33.0	31.8	33.3	35.3	33.5	34.4	34.4	33.0	33.9	33.8	1.2	6
#4 bottom	7.4m	33.0	31.8	33.3	35.3	33.0	34.4	34.4	33.3	34.4	33.9	1.3	6
#5 surface		31.2	31.8	32.5	35.0	33.3	34.4	33.3	33.3	33.9	33.3	1.5	6
#5 bottom	9.2m	31.2	31.5	32.0	35.3	33.2	34.4	34.4	33.5	34.4	33.5	1.7	6
#6 surface		31.5	31.8	31.0	34.4	33.4	35.0	33.9	33.2	33.9	33.4	1.4	6
#6 bottom	7.2m	31.5	31.8	30.8	35.5	33.3	34.4	33.3	33.2	33.9	33.4	1.5	6
#7 surface		31.8	31.5	33.3	35.5	33.8	34.4	34.4	33.2	33.9	33.6	1.6	6
#7 bottom	8.6m	31.8	31.5	33.3	35.5	33.3	35.0	34.4	33.2	33.9	33.7	1.7	6
#8 surface		31.5	31.5	33.0	35.0	33.0	33.9	33.3	33.2	34.4	33.2	1.5	6
#8 bottom	12.4m	31.5	29.2	33.1	35.5	33.5	34.4	33.3	33.2	34.4	33.0	2.3	6
#9 surface		----	32.8	35.5	35.0	33.4	33.3	33.9	33.8	35.0	34.0	1.0	5
#9 bottom	7.1m	----	32.8	35.5	35.5	33.4	33.3	33.9	33.8	35.0	34.1	1.1	5
surface		31.4											

Table 9. Dissolved oxygen measurements (mg/ℓ) at the eight water quality monitoring stations and control stations. Grand mean is the mean of all dissolved oxygen measurements at the water quality monitoring stations.

STATION	DEPTH	MAY 20	MAY 30	JUNE 1	JUNE 2	JUNE 26	JULY 7	JULY 21	AUGUST 4	$\bar{y}$	s	N
Station 1	surface	5.91	6.11	6.19	6.03	6.03	6.81	6.52	5.98	6.20	0.31	8
	bottom	6.48	6.19	6.03	6.36	6.52	6.48	6.19	5.98	6.28	0.21	8
	5m			6.03								
Station 2	surface		6.28	5.87	6.11	6.36	6.40	6.37	6.15	6.22	0.19	7
	bottom		6.19	6.36	5.95	6.03	6.32	5.87	5.98	6.10	0.19	7
	5m	5.87		6.52								
Station 3	surface		5.79	6.36	6.19	8.15	6.23	5.87	6.65	6.46	0.80	7
	bottom	6.44	6.11	5.87	6.03	6.19	6.15	6.01	5.65	6.06	0.23	8
	5m			6.36								
Station 4	surface		5.95	6.03	5.87	4.89	6.31	5.35	5.82	5.75	0.47	7
	bottom	6.19	6.03	6.44	6.19	4.40	6.81	6.10	5.98	6.02	0.71	8
	5m			6.19								
Station 5	surface		6.11	6.44	5.70	7.01	5.82	5.38	5.98	6.06	0.53	7
	bottom	6.36	5.87	6.19	5.87	4.89	6.15	6.19	6.15	5.96	0.46	8
	5m			6.36								
Station 6	surface	7.33	5.38	5.70	5.70	6.52	5.98	5.54	6.16	6.04	0.64	8
	bottom	6.68	6.19	6.11	5.87	6.52	6.32	6.36	5.98	6.25	0.27	8
	5m			6.44								
Station 7	surface		6.36	5.38	5.87	6.03	6.01	5.61	5.82	5.87	0.32	7
	bottom	6.03	6.19	6.44	6.19	6.36	5.73	5.97	5.82	6.09	0.25	8
	5m			6.52								
Station 8	surface		5.62	6.11	6.03	5.87	5.98	6.03	5.82	5.92	0.17	7
	bottom	6.19	6.03	6.11	6.11	6.03	5.98	5.95	5.98	6.05	0.08	8
	5m			6.68								
Station 9	surface					6.36	7.31	6.60	6.15	6.61	0.50	4
	bottom					6.19		5.87	6.15	6.22	0.32	
	5m				6.28		6.65					

Grand Mean = 6.08 ± 0.36 mg/ℓ.

Table 10. Total phosphorus concentrations at the eight water quality monitoring stations and control stations (stations 9). Concentrations are in mg/ℓ. Mean values are for all measurements at each station combined.

STATION	DEPTH	MAY 20	JUNE 2	JUNE 26	JULY 7	JULY 21	AUGUST 4	$\bar{y}$	s	N
Station 1	surface	024	.020							
	bottom	.030	.059							
	5m			.013	.022	.012	.014	.024	.015	8
Station 2	surface	.030	.032							
	bottom	.017	.023							
	5m			.013	.017	.014	.021	.021	.007	8
Station 3	surface	.024	.020							
	bottom	.021	.026							
	5m			.012	.024	.014	.015	.019	.005	8
Station 4	surface	----	.030							
	bottom	.030	.023							
	5m			.015	.028	.019	.018	.023	.006	7
Station 5	surface	.038	.017							
	bottom	.019	.020							
	5m			.020	.012	.011	.014	.019	.008	8
Station 6	surface	.046	.023							
	bottom	.043	.022							
	5m			.013	.012	.014	.018	.024	.013	8
Station 7	surface	.020	.030							
	bottom	.091	.024							
	5m			.022	.015	.017	.012	.029	.026	8
Station 8	surface	.020	.021							
	bottom	----	.023							
	5m			.025	.025	.012	.014	.020	.005	8
Station 9	bottom	----	.021							
	5m			.012	.009	.012	.011	.013	.004	5
	surface	.014								

Table 11. Total kjeldahl nitrogen concentrations at the eight water quality monitoring stations and control stations. Concentrations are in mg/ℓ.

STATION	DEPTH	MAY 20	JUNE 2	JUNE 26	JULY 7	JULY 21	AUGUST 4
Station 1	surface	.059	.080				
	bottom	.542	.099				
	5m			.010	.050	.060	< .010
Station 2	surface	.167	.029				
	bottom	.167	.041				
	5m			.050	.020	.050	.010
Station 3	surface	.234	< .010				
	bottom	.084	.010				
	5m			.041	.041	.090	.029
Station 4	surface	.034	.070				
	bottom	.017	.010				
	5m			.011	.055	.041	.020
Station 5	surface	.267	.010				
	bottom	.181	.309				
	5m			.070	.041	.080	.041
Station 6	surface	.150	.090				
	bottom	<.010	.111	.120	.070	.020	.020
	5m						
Station 7	surface	<.010	.010				
	bottom	.482	.070				
	5m			.099	.111	.010	.010
Station 8	surface	<.010	.010				
	bottom	<.010	.056	----	.055	.020	.020
	5m						
Station 9	bottom		.109				
	5m			.029	.020	.090	.020

Table 12. Heavy metal analyses of water samples collected at 5 meter depths from the eight water quality monitoring stations and the control station (Station 9). Concentrations in mg/ℓ.

STATION	Zn	Cu	Pb	Hg	As
1	<0.05	<0.05	<0.05	<0.0010	<0.01
2	<0.05	<0.05	<0.05	<0.0010	<0.01
3	<0.05	<0.05	<0.05	<0.0010	<0.01
4	<0.05	<0.05	<0.05	<0.0010	<0.01
5	<0.05	<0.05	<0.05	<0.0010	<0.01
6	<0.05	<0.05	<0.05	0.0050	<0.01
7	<0.05	<0.05	<0.05	<0.0010	<0.01
8	<0.05	<0.05	<0.05	0.0290	<0.01
9	<0.05	<0.05	<0.05	<0.0010	<0.01

Table 13. Water quality data collected in three previous environmental studies of Truk Lagoon waters (see Literature Cited section of report for authors and dates of reports).

	TEMPERATURE (°C)				SALINITY (‰)				DISSOLVED OXYGEN (mg/ℓ)				NITRATE-NITROGEN (mg/ℓ)				PHOSPHATE-PHOSPHORUS (mg/ℓ)			
STUDY-SITE	$\bar{y}$	RANGE	s	n	$\bar{y}$	RANGE	s	n	$\bar{y}$	RANGE	s	n	$\bar{y}$	RANGE	s	n	$\bar{y}$	RANGE	s	n
Gabert Pt., Moen	28.4	28.1-28.5	0.2	14	32.9	32.2-33.8	0.5	12	5.78	4.8-6.2	0.47	12	.004	.004	<.001	5	.007	.007-.008	<.001	5
Dublon Is.	29.+	28.5-32.0	---	91	34.4	34.4-35.5	<0.1	18	6.52	5.50-8.80	0.59	91	.004	.002-.010	.002	9	.005	.004-.006	<.001	9
Tol Island		28.8-30.3				33.3-35.0			7.15	1.17-8.88	0.71	24	.004	.001-.008	.002	14	.005	.004-.009	.001	14

Table 14. Air particulate sampling results in micrograms per cubic meter of filtered air (μg/m^3). The daily sampling period was 24 hours, unless otherwise noted.

DATE	WEATHER STATION	QUARRY
6/20/78	16.9	13.8
6/21/78	7.8 *	15.5
6/22/78	18.8	16.7
6/23/78	1.4 **	41.5
6/24/78	9.9	12.1
6/25/78	12.6	8.4
6/26/78	26.8	10.9
6/27/78	23.2	----
Geometric Mean	17.1	14.9

* Exact sampling time unknown, assumed to be 24 hours.

** Sampling time - 3 hours, 13 minutes. Not included in geometric mean.

Table 15. Activity peak noise levels, background noise levels, and Ldn values for the three noise monitoring stations.

WEATHER STATION	dB(A)	QUARRY SITE	dB(A)	POU BAY CAUSEWAY	dB(A)
Plane Taxing to Airport Terminal	105.6	Quarry Site Crusher	89.5	Commercial Airliner (B727) Taking-Off	87.7
Plane Taking-Off	99.7	Heavy Traffic on Frontage Road	83.0	Boats Arriving and Departing Boat Dock	84.5
Plane Landing	95.0	Rain Shower and Associated Wind Noise	82.0	Net Fishermen Shouting	84.0
Plane at Rest with Engines On	92.3	General Quarry Operations	81.0	Rain Squall and Associated Surf Noise	82.7
Bulldozer Operating Near Runway	89.5	Jet Landing at Airport	80.0	Insects and Crustaceans at Night	80-90
Heavy Traffic on Access Roads	60.0	Dog Barking	79.5	Commercial Airliner Landing Approach	71.0
Light Traffic on Access Roads	51.0	Wind Gusts and Associated Noise	76.5	Traffic on Causeway Road	64.5
Mean Background Noise Level 8AM-5PM	45.5	Pig Squeals	57.0	Mean Background Noise Level 8AM-5PM	41.4
Mean Background Noise Level 10PM-7AM	42.0	Light Traffic on Frontage Road	57.0	Mean Background Noise Level 10PM-7AM	54.1
Mean Peak Noise Level for 24 Hours	78.3	Quarry Crane Engine Noise	55.5	Mean 24 Hour Peak Noise Level	73.2
Minimum Noise Level	37.0	Mean Background Noise Level 8AM-5PM	54.1	Minimum Noise Level	32.0
Ldn	48.7	Mean Background Noise Level 10PM-7AM	54.0	Ldn	48.1
		Mean 24 Hour Peak Noise Level	76.4		
		Minimum Noise Level	41.5		
		Ldn	58.1		

APPENDIX

The following are detailed descriptions of the nine water quality stations.

Station 1 - is east of Pou Channel on a prominent outcropping of the East Pou Reef margin (Fig. 3). This lagoonward extension of the reef margin is bordered on the east and west by small sandy indentations. The station is ca. 20m lagoonward of the central portion of the outcropping at an average depth of 8m on the western side of a coral/sand ridge.

Station 2 - is west of Pou Channel on a major extension of West Pou Reef (Fig. 3). A white channel marker is located on the lagoonward tip of the reef flat projection. The station is ca. 25m lagoonward of this marker bouy in a large Porites coral head. The base of the Porites head is at an average depth of 7m. The surrounding area is sandy and rapidly descends to ca. 15m lagoonward.

Station 3 - is off the arm east of a large indentation on the West Pou Reef margin (Fig. 3). East of the station is a large narrow indentation. Visible on the lagoonward tip of the east arm is a large table-top Acropora. This arm descends northward as a broad ridge to a depth of approximately 16m. The station is 10-12m north of a table-top Acropora at an average depth of 8m.

Station 4 - is off the arm west of the large indentation on the West Pou Reef margin (Fig. 3). The tip of the arm is composed primarily of coral rubble with slope rapidly descending to the lagoon floor on the west side. The gentle eastern sandy slopes have numerous low coral rubble mounds. The station is lagoonward of the coral rubble tip on the western side of the ridge at a depth of 7m.

Station 5 - is off the reef margin across from the center of the Metitiu Reef dredge area (Fig. 3) at a depth of 9m. The station is on a north-south line with the artificial rock pier. The bouy is attached to a coral/rubble mound 68m from the reef margin and lagoonward extent of the pier. The surrounding area is primarily sand slope with sparse large coral/rubble mounds. The sand slopes descend rapidly lagoonward (north) to depths in excess of 15m.

Station 6 - is west of Metitiu Reef off the northeast end of the runway on a coral rubble mound (Fig. 2). Inshore and just west of the station is a small rock jetty (length 35m) with a small rock breakwater on the western side. The station is 85m lagoonward of the tip of the rock jetty at a depth of 7m. The coral rubble mound is isolated by a narrow sand patch. Numerous coral/rubble mounds surround the station.

Station 7 - is off of the central portion of the runway (Fig. 2) at a depth of 9m. The station is midway between the 2000/3000 ft. markers on the existing runway. The bouy is attached to a massive Porites head 140m from the existing runway shoreline. The coral mound is surrounded by an extensive sand slope. The surrounding sand slopes have an average depth of 9m.

Station 8 - is off (north) of the southwestern end of the runway in the vicinity of the Point Gabert sewer outfall diffuser on a low rubble mound (Fig. 2) at a depth of 12m. Station 8 is approximately 30m northwest of the sewer outfall diffuser and is 115m from the shoreline. The low rubble mound ranges in depth from 10.2-12.5m.

Station 9 - is on the eastern side of a large patch reef that lies approximately half-way between Moen and Fano Islands (Fig. 3) at a depth of 7m. The periphery of the patch reef in the vicinity of the station rapidly descends to depths in excess of 20m. The station is a large rubble mound surrounded by sand patches.