CCOP/SOPAC Engineering Report 2

20 June 1988

WATER QUALITY MONITORING SURVEY IN QUEEN SALOTE WHARF AREA NUKU'ALOFA, TONGATAPU, KINGDOM OF TONGA

8 December 1987

by

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Techsec

Prepared for: Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC) Tonga Project CCSP/TG.8

Contributed by: ESCAP/UNDP Project RAS/86/125, Development of South Pacific Institutional Capability in Marine Minerals & Technology

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SUMMARY

A post-construction and dredging water quality survey was conducted in the waters near Queen Salote Wharf on 8 December 1987. The objective of the survey was to determine whether the water quality in the lagoon area had experienced any change following the dredging in the fishing harbour. Seven sampling stations were occupied including one in the newly developed fishing harbour. Six of the stations were the same stations as used in the pre-construction, 1984 water quality monitoring survey (Carter, 1984).

Changes in the water quality were observed between the surveys made prior to and following the construction and dredging operations. A reduction in the transparency of the water to one-third of the pre-construction transparency was observed. While some changes in the plankton concentration were measured they appeared to be minor. A significant amount of suspended material was found inside the fishing harbour although it does not appear to be the sole source of the turbidity responsible for the reduction in transparency observed during the survey. Re-suspension of fine material from deposits located to the east of the harbour may have contributed to the reduction in the transparency of the lagoon water during the

1987 survey; however, the existence of this deposit has not been confirmed. The rains that following a long dry period contributed in a minor way to the reduction in the transparency of the lagoon waters.

The water quality monitoring should be repeated during a time of minimum rainfall and following a period of significant wave action in the lagoon area. The survey should include sediment sampling for possible deposits of fine material that can be re-suspended by wave action.

INTRODUCTION

A post-construction and dredging water quality survey near Queen Salote Wharf on Tongatapu was requested after completion of the new fishing harbour located adjacent to Queen Salote Wharf. An assessment of water quality in the area had been made in 1984 prior to a proposed sand dredging operation and development in the Queen Salote Wharf area (Carter, 1984). A post-dredging monitoring made on 8 December 1987 utilized the baseline data developed in the 1984 study, and is the subject of this report. The survey is part of the Tonga work program for Coastal Development, CCSP/TG.8.

A significant amount of rain occurred a few days before the monitoring. As that rain was the first to follow a long dry period, a considerable amount of fine particulate matter and soluble nutrients were washed from the land area into the lagoon waters where water quality was to be monitored. This condition caused a temporary increase in the turbidity of the water due to suspended solids and increased plankton growth. As a result it was decided that a full scale water quality monitoring should not be conducted at this time as much of the effort would be wasted on a condition that could not be compared with that of the pre-dredging study. A reduced monitoring was done after the effect of the rain had dissipated.

The coral reef adjacent to the harbour and that in the nearby marine reserve are resources that could be impacted from the dredging activity. If the coral is not damaged then other marine resources are unlikely to be affected significantly. The dredging could release toxic substances, cause shoaling of particulate matter, and increase turbidity of the water all of which are known to have a negative impact on the coral when in excess. Waste water discharged in the harbour area from any

source such as ships or the wharf facilities could also have an impact.

Under conditions found in the Queen Salote Wharf area toxicity due to hydrogen sulfide in the dredging spoils would be present only during dredging. The BOD (bio-chemical oxygen demand) loading within the fishing harbour at the time of the survey was estimated to be insignificant, so resuspension of fine particulate matter released during the dredging would likely be the greatest hazard that could be readily evaluated. Hence, the turbidity of the water was the parameter measured. The transparency of the very clear Tonga waters is sensitive to most pollutants. Turbidity can be caused by plankton as well as inorganic suspended solids, so net plankton were collected in order to estimate their contribution to the turbidity in the water. A secchi disc was used to measure the transparency of the water.

OBJECTIVES

The objective of the 1987 survey was to evaluate the water quality of the lagoon area around Queen Salote Wharf and determine if the water quality had changed owing to dredging of the fishing harbour. This activity is part of the 1987 Tonga work programme, CCSP/TG.8.

IMPLEMENTATION

Personnel participating

The survey was conducted by Ralf Carter, Marine Scientist. Support and assistance was provided by the Ministry

of Lands, Surveys and Natural Resources. Individuals assisting in the activity included:

Mr. Sione L. Tongilava, Permanent Secretary, Ministry of Lands Surveys and Natural Resources;
Mr. Sione Soakai;
Mr. Hap Pikotoa.

Equipment and facilities

The following equipment was provided by CCOP/SOPAC:

Chart (Hydrographic Office, British Admiralty, 1971);
Secchi disc, Plankton Net and Accessories;
Sea Chest and Tools;
Miscellaneous Lines.

The facilities and equipment supplied by the Government of Tonga included the following:

Boat, Fuel, and Engine;
Crew and Land Support;
Transport.

PROJECT SITE

The study area is on the north side of Tongatapu near Nuku'alofa (Fig. 1). During the 1984 water quality survey the survey party had occupied seven stations, and six of those stations and the fishing harbour were reoccupied in the course of the present study (Fig. 1). As Station 6 in the 1984 survey

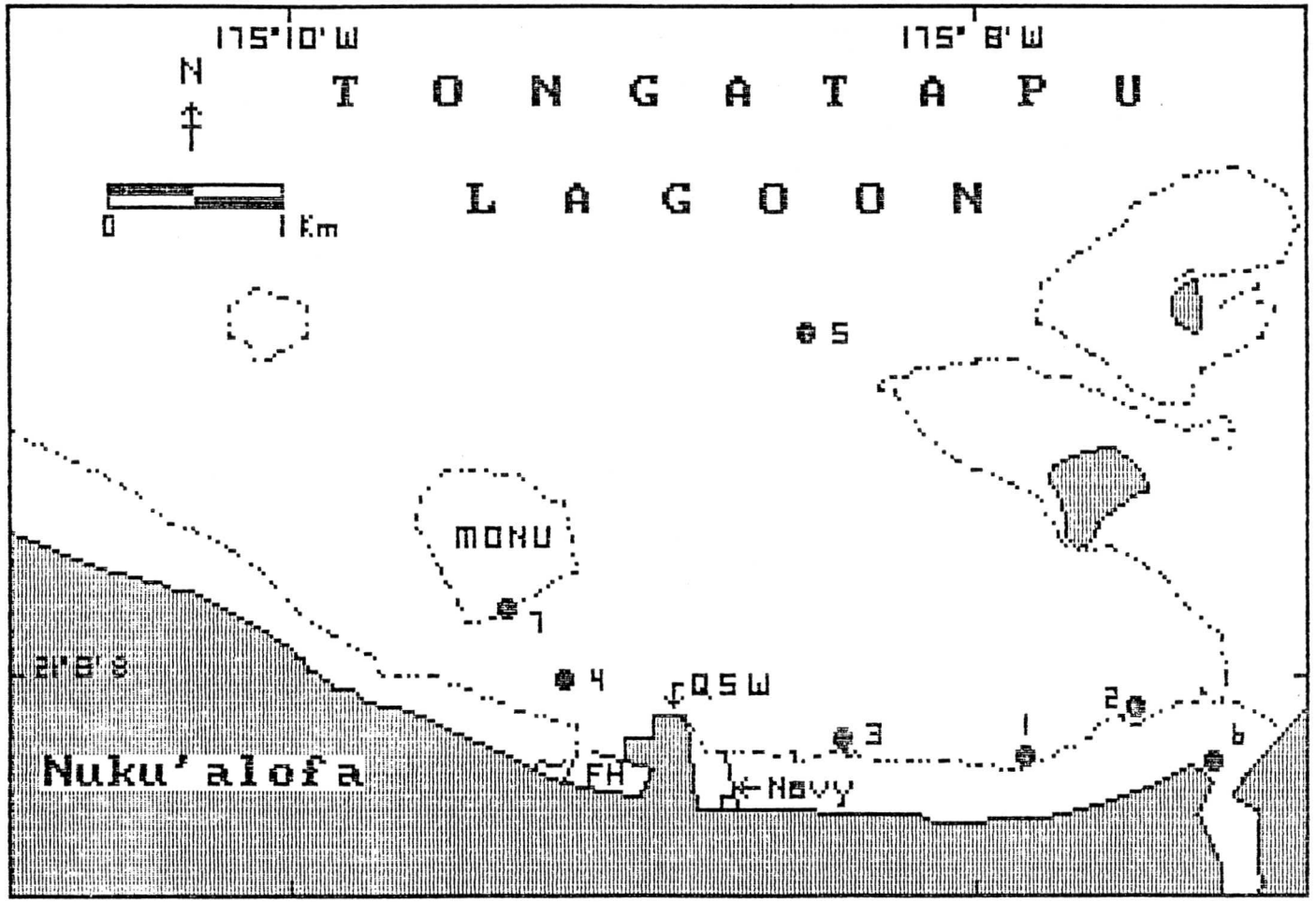

FIGURE 1 - Location Map Showing Seven Monitoring Stations (1-7) The Fishing Harbour (FH) and Queen Salote Wharf (QSW)

did not contribute to the present objectives, it was not occupied. Station 5 was needed as the control because it is located in an area where the water column is replaced with ocean water more frequently than the waters adjacent to the wharf.

METHODS

A total of 6 stations and the fishing harbour were sampled. The observations were made using the same methods employed in the 1984 survey (Carter, 1984), so a direct comparison can be made between values obtained during the two survey periods.

The transparency of the water was the significant water quality parameter used in the present study. The Secchi disc value, a measure of water transparency, is inversely related to the amount of turbidity in the water. A greater than value (>) indicates the depth of water where the observation was made and that the disc could be seen from the surface when it was on the bottom. The depth at which the disc can just be seen is the reported transparency or Secchi disc value.

RESULTS

The results from both surveys are given in Table 1.

DISCUSSION

The 1987 survey was done during the end of flood tide, mean low high water, and the beginning of ebb tide. A weak ocean current near stations 1, 2, and 3 set to the west for that part of the tide cycle during the 1984 survey when currents were

TABLE 1

RESULTS OF MONITORING SURVEYS
10 February 1984 and 8 December 1987

Station No.	Time (hr)	Secchi (m) 1984	Secchi (m) 1987	Plankton (ml/cm) 1984	Plankton (ml/cm) 1987	COLOUR 1987
1	0925	13.4	4.3	1.91	1.79	Milky Green
2	0857	>10	8.5	-	2.23	Milky Green
3	1002	10.4	12.2	3.83	3.57	Greenish Blue
4	1050	>12.4	9.8	0.13	3.19	Light Blue
5	1149	16.2	14.3	2.55	0.89	Blue
7	1112	-	12.2	-	1.79	Blue
Harbour	1032	-	1.5	-	-	Milky Green

measured. The currents appeared to be the same during the 1987 survey except for the surface water which had a northwest drift due to a 5 to 8 knot southerly wind. There were scattered clouds during the 1987 survey. The seas were low as the monitoring area was in the lee of the island. The vessel was anchored while observations were made.

Three days prior to the 1987 survey turbid water in the reef area near Atata Island on the west side of the lagoon limited visibility to about 8 metres. This turbidity was visible all along the reef bordering Nuku'alofa and to the east of Queen Salote Wharf. The turbidity appeared to be due to the

recent rain and to be temporary. Three days later during the survey the waters west of the Monu Reef toward Atata Island were quite clear, an indication that the tidal exchange had diluted or moved this turbid water elsewhere. Some of the turbidity present at the monitoring stations during sampling could have been the result of the proceeding rain. However, in the author's opinion turbidity from the rain was a minor part of the turbidity sampled; most appeared to come from the re-suspension of fines accumulated near the reef face at Station 1, and it could be seen coming also from the fishing harbour.

The ocean and tidal currents in the vicinity of Station 1 are weak, so suspended fine material can settle along the face of the reef when wave action is minimal and the water is quiescent at the reef face. The wind had changed direction several times just prior to the time of the survey. Part of the time it came from a northerly direction. As there is no known local land source for turbidity at Station 1, wave action appeared to have re-suspended the fines that were deposited there. Turbidity was much higher near Stations 1 and 2 in 1987 than in 1984 (See Fig. 2 and Fig. 3).

At Station 1 the water transparency in 1987 was reduced to approximately one third the value recorded in the 1984 survey. The amount of net plankton collected was about the same in both surveys.

At Station 2 the transparency was less than that measured in 1984. However, it was twice the value found at Station 1 indicating that the source of the turbidity was in the vicinity of Station 1.

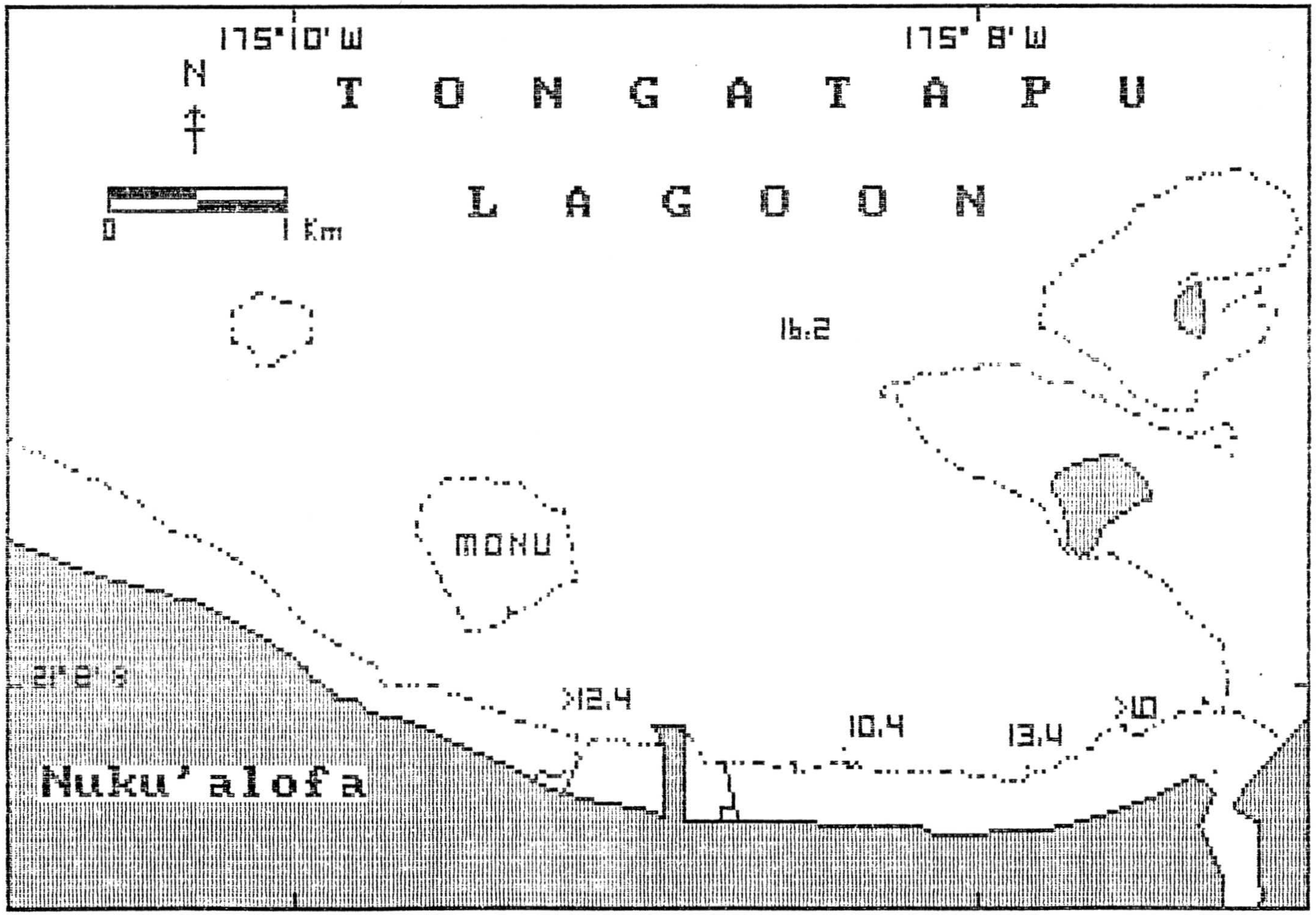

FIGURE 2 - Secchi Disc Transparency in Metres Observed During the 1984 Monitoring Survey

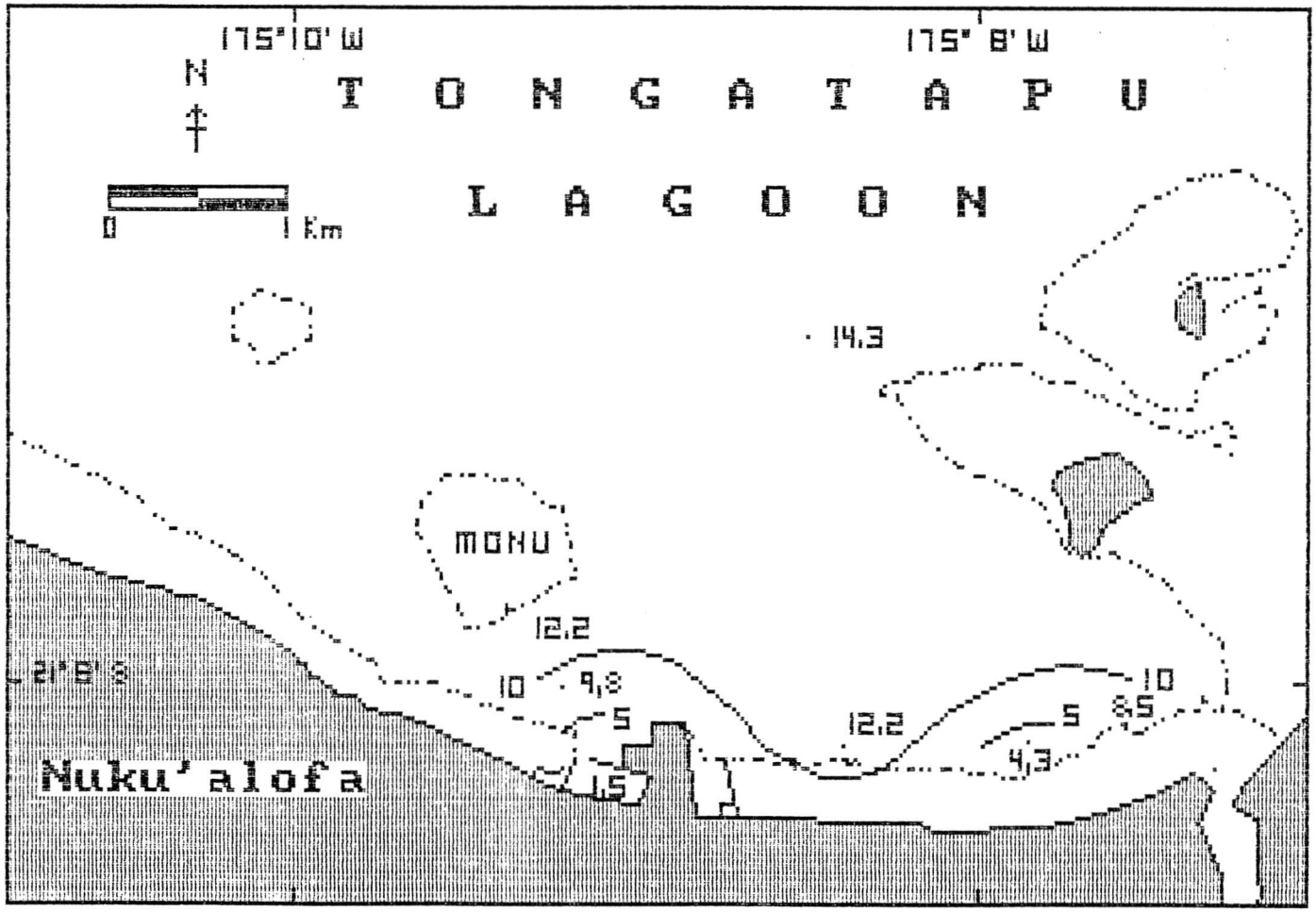

FIGURE 3 - Secchi Disc Transparency in Metres Observed During the 1987 Monitoring Survey

At Station 3, which is closer to the fishing harbour than both Station 1 and 2, the transparency of the water was greater during the post dredging survey, that is the water was clearer. The amount of net plankton was only slightly less during the post-dredging survey than that found during the pre-dredging survey.

In 1987 the turbidity of the water was high within the fishing harbour. The transparency was only 1.5 metres. Very little of this turbid water was being removed by the tidal exchange. It was constantly being replaced by the turbulence produced from the wash of boat propellers over the soft bottom. Station 4, west of the harbour entrance (Fig. 1) did show an increase in turbidity over the pre-dredging condition. It was evident from the turbidity of the water as seen from the surface that the currents set to the west at the harbour entrance. The higher turbidity to the west rather than to the east of the entrance also indicates a western set of the currents at the time of sampling. The increase in turbidity at Station 4 shows that the harbour is contributing some turbidity to the lagoon waters.

The turbid water leaving the harbour should cause a density current and drift toward deeper water except during times of strong wave surge that can mix the turbid water with the entire water column. During those times the turbidity from the harbour and other sources can be dispersed over much of the nearby lagoon waters. When the water becomes quiescent the turbidity will settle and in areas where turbulence is low these fines tend to accumulate. Station 1 is in the lee of a long, curved reef projection that has a small island that would reduce wave action at the station. The area could also be nodal with respect to tidal currents, and if this is the case the fine particulate matter would tend to shoal there. Such material can

be recycled many times until a major storm removes it to deep water. This mechanism could explain why the water near Station 1 appears to be a source of turbidity.

The transparency of the water at Station 7 was somewhat less than the water at Station 5, the control station. This water would be expected to contain some of the residual suspended solids from the heavy rain as well as some of the fine material being discharged from the fishing harbour.

The reduced transparency of the water at Station 5 appears to be due to the recent rains as well as other sources that may be associated with the harbour and wharf development. This reduction in transparency was on the order of 12 percent, and while that concentration could have the effect of reducing the rate of growth in the coral it would not impact the coral in a serious way. If the increased turbidity seen at Station 1 persists then it would be expected to reduce the rate of coral growth significantly, and it could inhibit the attachment of new coral near the bottom of the reef face. Some coral damage can be expected where fine particulate material settles to the bottom in sufficient amount to suffocate the coral. In a similar way some damage to the coral can be expected outside the entrance to the fishing harbour (Zoland and Clayshulte, 1978; Randall and Birkeland, 1978; Risk, 1983). However, the 1987 survey did not include observations that assess coral damage or verify a fines deposit or shoal located near Station 1. Additional observations are required to evaluate these conditions.

A preliminary draft of construction phase guidelines written 25 July 1984 (Appendix I) recommended that the construction and dredging activity should be done only behind a watertight barrier to prevent high concentrations of turbid

water reaching the nearby reef coral and accumulating as shoals in the area. Apparently the dredging was made within an impounded area. However, there are several unsubstantiated reports of very turbid water being pumped from the impounded area across the wharf and discharged freely into the ocean between Queen Salote Wharf and the Navy Base causeway to the east. This was apparently done to maintain a lower water level within the impounded basin during dredging. No record of the amount of material discharged in this manner, how long this pumping was maintained, or how much material was excavated during the dredging operation was made available to this survey. This practice of discharging turbid water from the enclosed dredging area to the open lagoon defeats the purpose of impounding the dredging area.

A primary objective of environmental surveys is to ensure the protection of the people. The high turbidity of the water within the fishing harbour makes swimming dangerous. Diving onto submerged objects and disorientation when submerged are two of the dangers. Locating a diver or swimmer submerged in turbid water can be difficult. Therefore recreational swimming within the harbour should be discouraged until the transparency of the water has improved.

CONCLUSIONS

The conclusions reached from this water quality monitoring are based upon the information available and observations made during the monitoring activity, and they are subject to modification with additional information. The conclusions are:

1. The turbidity of the lagoon water near Queen Salote Wharf

was greater at the time of the 1987 survey than during the 1984 survey apparently due to turbid water being discharged from the fishing harbour.

2. There was a 300 percent decrease in water transparency at Station 1 from that observed in the 1984 water quality survey. If this increased turbidity occurs frequently it will have a negative impact on the live coral nearby.

3. There may be a significant source of fine material near Station 1 that can increase the turbidity of the lagoon water at that station.

4. The turbidity of the water within the 4 metre deep fishing harbour was high, and will probably remain high until the fine harbour sediments are stabilized or removed so that they are not suspended by boat propeller wash.

5. There was increased concentration of suspended solids in the lagoon water due to the recent heavy rainfall. The increase was estimated to be on the order of 12 percent during the water quality survey.

6. Fine material that may have accumulated in the reef area since the dredging activity would be expected to be removed from the area into deeper water during a major storm such as a hurricane.

RECOMMENDATIONS

The following recommendations are based upon the findings of this water quality monitoring survey, and the author's

experience elsewhere with water quality programmes.

1. The sediments within the fishing harbour should be cored to a depth of at least one metre to determine the extent, amount, and texture of fine material on the bottom.

2. Some system to stabilize the sediments within the fishing harbour should be considered. A layer of the fines could be removed, then the remaining sediments covered with a coarse gravel or rock to armour the bottom against propeller wash .

3. The sediments should be sampled at the water quality sampling stations during a future monitoring exercise. Additional samples should be collected between Queen Salote Wharf and Station 2 in an effort to locate any shoals of fine material of recent origin in that area.

4. Any significant shoals found in 3 above should be delineated and sampled.

5. Swimming within the fishing harbour should be prohibited as long as the present level of turbidity remains.

6. A water quality monitoring programme for the waterfront area should be developed and the surveys made on a regular schedule. Data resulting from such a program would show when melioration is required.

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1. The views expressed in this report are those of the Author and do not necessarily reflect those of the United Nations.

2. Mention of any firm or licensed process does not imply endorsement by the United Nations.

APPENDIX I

A telegram sent 25 July 1984 to Mr. S. L. Tongilava
Ministry of Lands and Natural Resources

ENVIRONMENTAL IMPACT OF SMALL CRAFT DEVELOPMENT ON NUKU'ALOFA WATER FRONT

A: The development planned will have serious negative short term and long term impacts upon nearshore waters and adjacent reef areas unless adequate environmental control measures are taken during and following the construction phase.

B: Preliminary Draft of Construction Phase Guidelines: The turbidity produced during dredging unless contained within the construction area by a watertight barrier must be kept at a low concentration so not to kill the reef coral or cause a significant deposition of sediment on the reef and foreshore area. The allowable concentration of turbidity would be established following a detailed evaluation of the particles size, duration of exposure and controlling coral species. The allowable deposition will require a similar analysis. Further evaluation of possible increase in nutrients, hydrogen sulfide, bio-chemical oxygen demand, BOD, will also be required in order to specify water quality control parameters during construction. Some control on blasting will be required.

C: Preliminary draft of post-construction water quality controls: Each type of development or activity that produces a discharge to the water or degrades the water quality will require specific regulation, monitoring and enforcement. Small boat activities require regulation of paint, domestic waste, oil and fuel, floatables, fish cleaning, bacterial pollution, BOD, odor control, fuel storage, fire hazards, spillage etc. Future maintenance dredging etc.

The above guidelines are for general planning only and a detailed study of the proposed project is required to develop adequate regulations and enforcement procedures.

Sincerely Yours

Dr. Ralf Carter, CCOP/SOPAC Marine Scientist