FUTURE WATER QUALITY MONITORING PRIORITIES FOR THE TRUST TERRITORY OF THE PACIFIC ISLANDS

Peter A. Cowan

Water Resources Research Center

UNIVERSITY OF GUAM

Technical Report No. 16

June 1980

OFFICE OF WATER RESEARCH AND TECHNOLOGY

PROJECT NO. A-020-GUAM

FUTURE WATER QUALITY MONITORING PRIORITIES

FOR THE

TRUST TERRITORY OF THE PACIFIC ISLANDS

By

Peter A. Cowan

UNIVERSITY OF GUAM

Water Resources Research Center

Technical Report No. 16

June 1980

Partial Completion Report

for

THE INFLUENCE OF MODERN WATER SUPPLY AND

WASTEWATER TREATMENT SYSTEMS ON WATER

QUALITY IN MICRONESIA: PHASE I

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

Principal Investigator: Peter A. Cowan

Project Period: April 1, 1980 to September 30, 1980

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

Implementation of a comprehensive water quality monitoring program is not possible at the present time in the Trust Territory of the Pacific Islands (TTPI). Due to the remoteness of these islands, any routine monitoring must be accomplished by local district sanitation officers. Formulation of monitoring strategies must satisfy objectives which are realistically attainable based upon the contraints of manpower, time and finances.

The highest priority monitoring strategy is the one which must be developed for the public water system (PWS). Total Coliform (TC), Free Residual Chlorine (FRC) and Turbidity analyses must be performed at least twice per month on water samples representative of the entire PWS in order to insure the delivery of safe drinking water to the public served by these systems. It is imperative that FRC be checked daily; any violations of standards must be reported to the Environmental Protection Board (EPB) within 48 hours. The PWS data should be reported to the EPB once per month.

A second monitoring scheme must evaluate the marine environments surrounding the various district centers. Fecal Coliform (FC), FRC and Turbidity should be monitored at representative sites at least twice per month. The marine water quality results should be reported to the EPB once per month.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

INTRODUCTION

The Federal Water Pollution Control Act (P.L. 92-500) was passed into law in 1972 with the highly idealized goal of attaining "zero discharge" of pollutants into surface waters by 1985. Extensive capital improvement projects have been established in order to attempt to reach this goal. Evaluation of this massive investment is accomplished through water quality monitoring programs:

i. 208 Program - identification of background (baseline) levels of pollutants in surface waters;

ii. NPDES Permit (A National Pollutant Discharge Elimination System Permit is required for each point source attributed to domestic sewage and industrial waste discharges)

- evaluate performance of treatment schemes;

- assess impact of discharge upon receiving waters;

iii. Research - both public and private research and monitoring of surface waters.

Water pollution programs function with the purpose of either establishing or maintaining adequate water quality. Water quality standards have been established which insure both aesthetically pleasing waters as well as waters which pose no public health risks. The Marine Protection, Research and Sanctuaries Act (P.L. 92-532) was enacted in 1972 to establish monitoring programs specifically for marine environments. The Federal Safe Drinking Water Act (P.L. 93-523) was passed in 1974 and set forth water water quality standards for drinking water. Monitoring programs must comprehensively evaluate drinking water from its source to its various delivery points in order to assure safe drinking water.

Comprehensive water quality monitoring strategies must include physical, chemical and biological analyses; these analyses must quantify nutrients, toxic substances, and the so-called priority pollutants (naturally occurring and synthesized organic compounds). These monitoring strategies must establish sampling programs which satisfy objectives accounting for limitations of <u>manpower</u>, <u>time</u> and <u>monitary</u> constraints. The realistic appraisal of these constraints is the most important factor in development of future research programs in the Trust Territory.

The Trust Territory of the Pacific Islands (TTPI) covers approximately a three million square mile area in the western Pacific Ocean. The more than 2000 islands account for only 526 square miles of landed area (0.018% of the total area). Development of future research priorities concerning water pollution and water pollution control is an essential prerequisite to establishment of adequate monitoring; however, these strategies must realistically appraise:

i. the remoteness of these islands;

ii. the lack of adequate analytical equipment (instrumentation);

iii. the difficulties involved in establishing training programs for local environmental specialists and technicians;

iv. the limited sources of funding for such programs.

In order to establish an adequate water quality data base (baseline), and to train local personnel in water quality sampling and analytical techniques, implementation of monitoring strategies proposed herein will be initiated this summer (1980) in the district centers of Colonia (Yap) and Koror (Palau). Two 30 consecutive day monitoring programs (Colonia, June 1980; Koror, July 1980) have been funded by the Office of Water Research and Technology (OWRT); the study is entitled: "The Influence of Modern Water Supply and Wastewater Treatment Systems on Water Quality in Micronesia, Phase I". Phase II, scheduled for FY 1981 will expand the monitoring program to the district centers of Truk, Ponape and Kosrae. These projects will evaluate the practicality of the proposed monitoring strategies.

OBJECTIVES

Prioritization of future water quality research needs of the Trust Territory of the Pacific Island (TTPI) must include realistic appraisals of the capabilities of the district sanitation officers in terms of manpower as well as financial considerations. It is apparent that total implementation of a comprehensive monitoring program is not possible at the present time. It is the purpose of this report to outline only those strategies which are attainable now or in the near future. Specifically, the objectives include:

1. Identification of specific water quality monitoring strategies.

2. Determination of sample site locations and frequency of sampling.

3. Prioritization of water quality analyses to be performed including: equipment, chemical and supply requirements; personnel requirements; cost analyses.

4. Present, in outline form, recommended analytical techniques (including references) to be performed in district sanitation laboratories.

SUMMARY AND RECOMMENDATIONS
WATER QUALITY MONITORING STRATEGIES

I. Public Water Systems (PWS)

   1. Source of drinking water

   2. Processed Water

      a. Filtered Water

      b. Water After Chlorination

   3. Representative Delivery Points Throughout Distribution System

   4. Frequency of Sampling

      a. Daily Free Residual Chlorine (FRC) at Environmental Laboratory

      b. Water Source, Processed Water, Distribution System

         1) At Least Twice/Month

            a) Total Coliform (TC), FRC, Turbidity

            b) pH, Temperature

            c) Specific Conductance (EC)

         2) At Least Twice/Week - During Weeks When PWS is Not Sampled for TC

            a) FRC

II. Marine Water Quality - Class AA, A, B Waters

1. Areas Within Fringing Reefs and Bays

2. Boat Harbors and Docks

3. Areas Receiving Point and Non-Point Sources of Pollution

   a. Sewage Treatment Plant (STP) Outfall Sites

   b. River Input Sites and Estuaries

   c. Runoff and Storm Drainage

4. Frequency of Sampling

   a. At Least Twice/Month

      1) Fecal Coliform (FC), Free Residue Chlorine (FRC), Turbidity

      2) pH, Temperature

      3) Total Coliform (TC)

      4) Dissolved Oxygen (DO)

      5) Salinity - If Refractometer Available

III. NPDES Permit (National Pollutant Discharge Elimination System)

1. Evaluate Performance of Sewage Treatment Plant (STP)

   a. Daily Flow Measurements Should Be Obtained From Public Works

   b. Once/Month (STP Influent and Effluent)

      1) Biochemical Oxygen Demand (BOD_5)

      2) Suspended Solids (SS)

      3) Fecal Coliform (FC)

   c. Once/Month (STP Effluent)

      1) Setteable Solids

2) Free Residual Chlorine (FRC), Total Residual Chlorine (TRC)

3) pH, Temperature

IV. Reporting Procedure

1. Data Gathered Should Be Reported to (EPB) the Environmental Protection Board Once Per Month

2. Violations of Standards Should Be Reported to the EPB Within 48 Hours.

DISCUSSION

Implimentation of a comprehensive water quality monitoring program is not possible at the present time in the Trust Territory of the Pacific Islands (TTPI). Problems inherent with such a program are magnified by the fact that the TTPI will be dissociating into three distinct political entities (the Federated States of Micronesia, the Constitutional Government of the Marshall Islands and the Government of the Republic of Palau) on or before 1981. This report will, therefore, deal only with immediately achievable monitoring strategies; strategies which are to be developed for the local district sanitation offices. Satisfactory monitoring programs require representative sample site locations as well as sufficient sampling frequencies in order to achieve their objectives. Due to the extreme remoteness of the district centers of the TTPI, routine monitoring must be accomplished on the local level.

Types of monitoring programs, specific sites where samples are to be collected and the water quality parameters to be measured, will be prioritized. Monitoring strategies will be developed for the TTPI in its entirety utilizing information gathered in a recent marine baseline water quality study (Cowan and Clayshulte, 1980). Marine water quality was quantified in this study at the various district centers for the Marshalls, Palau, Yap, Truk, Ponape and Kosrae. Local environmental specialists assisted in sample collection and a portion of the analytical schedule was performed in the local district sanitation laboratories. Observations of local personnel, equipment (both laboratory and sampling) and supplies made during the baseline study serve as a basis for proposed monitoring strategies. The programs herein outlined will utilize the Koror area of Palau and the Colonia area of Yap as specific demonstration sites.

Public Water Systems

The highest priority monitoring scheme is the one which must be developed for the Public Water System (PWS). A complete sanitary survey of major municipal water systems in the TTPI was completed in 1977 (Young, et al); the monitoring strategies proposed in this study detail all aspects of district center water distribution systems and include recommendations for upgrading fresh water supplies. The Territorial Register (TTPI, 1978) outlines in detail a comprehensive monitoring program. It is imperative that the bacteriological phase of this comprehensive program be established and/or expanded.

Sampling points are selected which adequately represent the distribution systems. The proposed sample site locations for Koror and Yap are presented in Figures 1 and 2 respectively. The existing water distribution system for Koror is sampled at most once per month at seven points (Figure 1):

1. Public Works Garage
2. P.M.C.A. at T-Dock
3. Harris Elementary School
4. Maris Stella School
5. Tuker
6. Central Market
7. Tiul (last house)

Sporatic sampling has been performed at nine other locations:

8. Meyuns (last house)
9. Peleliu Club
10. Airai Water Treatment Plant, WTP (after filter)
11. Airai WTP (after chlorination)
12. Ngermid (private system)
13. Ngermid (public system)
14. Mokko

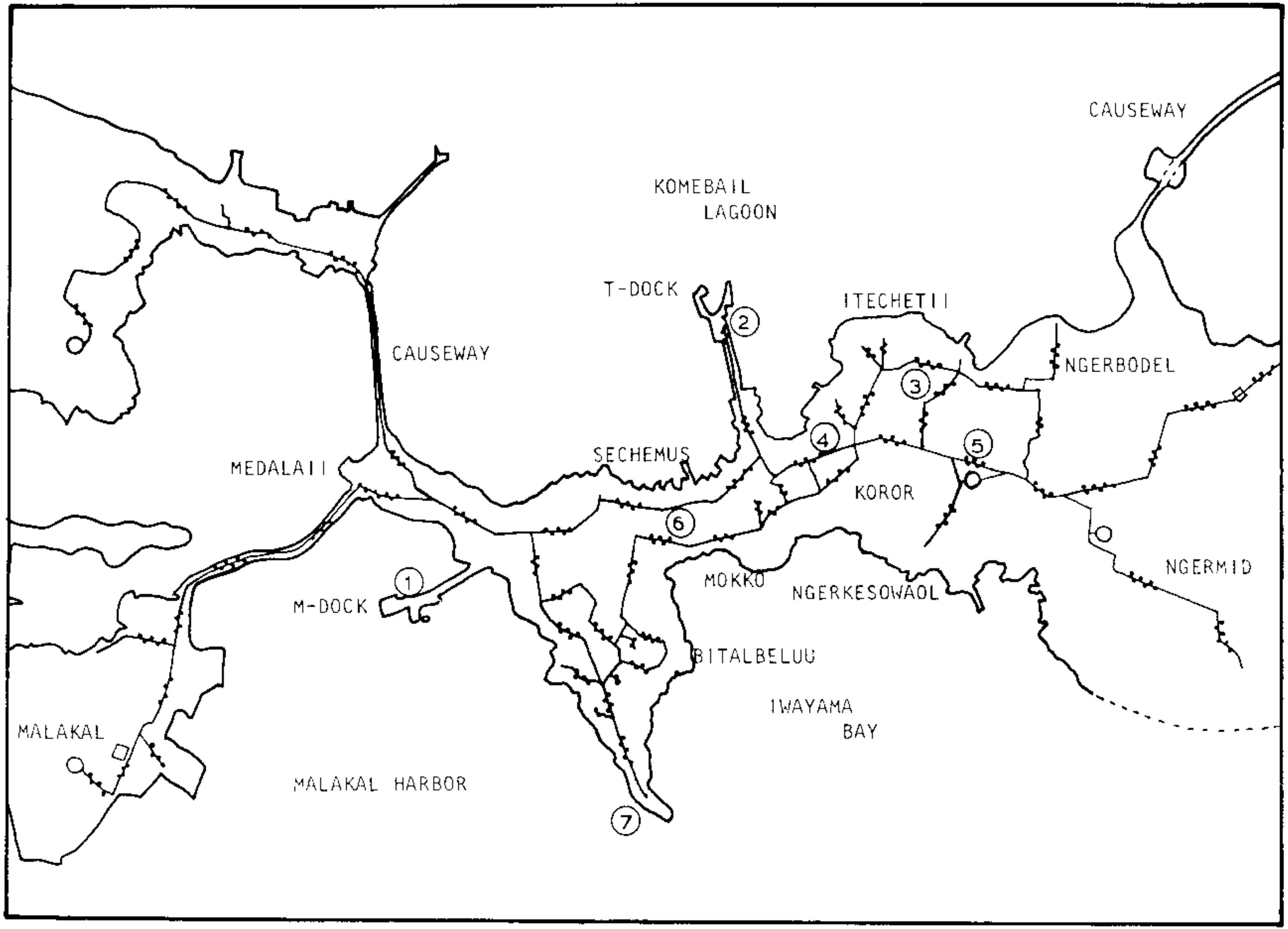


Figure 1. Water distribution system, Koror (Palau) municipal public water system.

15. Malakal fisheries

16. Continental Hotel

Specific water quality parameters analyzed include: Residual Cholorine, Total Coliform and Turbidity. The recorded data from October 1978 to March 1980 are listed in Table 1.

It is recommended that sampling sites 1,2,3,4,8,10,11,15 and 16 as well as the Environmental Laboratory (Area Sanitarian's Office - Macdonald Memorial Hospital) and Airai WTP influent be sampled on a regular basis in order to adquately represent the Koror Municipal PWS. Frequency of water distribution system sampling should be at regular intervals in proportion to the population served by that system (TTPI, 1978); Table 2. The estimated population served by the Koror Municipal PWS is 3600 people (based upon Public Works estimates of 450 service hook-ups and 8 people served/hook-up). Total Coliform analyses should therefore be performed at least four times per month.

Free Residual Chlorine (FRC) should be determined daily. Because of manpower constraints, it is recommended that this daily check be made at a water tap in the Area Sanitarian's Office. Values of FRC should equal or exceed 0.2 mg/ℓ.

Provisions are made (TTPI, 1978) for substitution of up to 75% of required coliform samples (Table 2) by analyzing the distribution system for FRC. Four FRC measurements should be taken for each substituted coliform sample.

Proposed sampling sites for the Colonia (Yap) water distribution system are presented in Figure 2. Ten sites were selected which would adequately represent the PWS:

1. Gitam Reservoir (source of drinking water)

2. Water Treatment Plant, WTP (processed water)

3. Senior High School (end of line)

4. Junior High School

5. Samoan Housing Area (end of line)

6. E. S. A. Hotel

7. Balabat (end of line)

8. Rai View Hotel

Table 1. Public water system monitoring data Koror, Palau.

Distribution Site Number	October 1978 Res. Cl_2*	Turb**	T.C.***	January 1979 Res. Cl_2	Turb.	T.C.	February 1979 Res. Cl_2	Turb.	T.C.	March 1979 Res. Cl_2	Turb.	T.C.	August 1979 Res. Cl_2	Turb.	T.C.	January 1980 Res. Cl_2	Turb.	T.C.	February 1980 Res. Cl_2	Turb.	T.C.	March 1980 Res. Cl_2	Turb.	T.C.
1																0,8		0	0.3	-	0	0.2	-	0
2	0	6.0	132	1.1	-	0	0,0.3	-	11,0	1.0	--	0	2	0.14	0	0,.4,0	5,3.5,-	0,0,8	0.2	-	0	0.2	-	0
3	0	-	3													0.2,0	3.5,3	0,7	0.2	-	0	0.4	-	0
4																			0.1	-	0	0.1	-	0
5				2.3	-	0				1.8	-	0	2	-	0	0,0	5.6,-	0,37	0.1	-	0	0.1	-	0
6	1	5.0	0							0.8	-	0	2	0.13	0	0,.4,0	5.6,2.8	0,0,0	0.1	-	0	0.2	-	0
7				0	-	0				0.2	-	0				0.4	4.6	0	0.2	-	0	0.1	-	0
				1.0	-	0																		
8	0	7.5	TNTC	0	-	100				0.2	-	0	2	0.15	0									
9	0	5.0	42	1.4	-	0	0.3	-	0	0.3	-	0												
10				0	0.04	82				0	-	TNTC												
11				2.4	1.0	0	0	-	-	3.5	-	0												
12				-	-	TNTC																		
13							0,0	-,-	54,2				0	-	****									
14										0.3	-	0	2	0,14	0									
15													0	0,13	TNTC									
16																			0	-	0			

* Res. Cl_2 = Residual Chlorine, mg/ℓ

** Turbidity, NTU

*** Total Coliform, #/100 mℓ

**** Confluent growth

Table 2. Frequency of coliform analyses for water distribution systems.+

Population Served	Minimum Number of Samples/Mouth
25 - 1000	1
1001 - 2500	2
2501 - 3300	3
3301 - 4100	4
4101 - 4900	5
4901 - 5800	6
5801 - 6700	7
6701 - 7600	8
7601 - 8500	9
8501 - 9400	10
9401 -10300	11
>10300	in accordance with EPB regulations

+Taken from TTPI (1978).

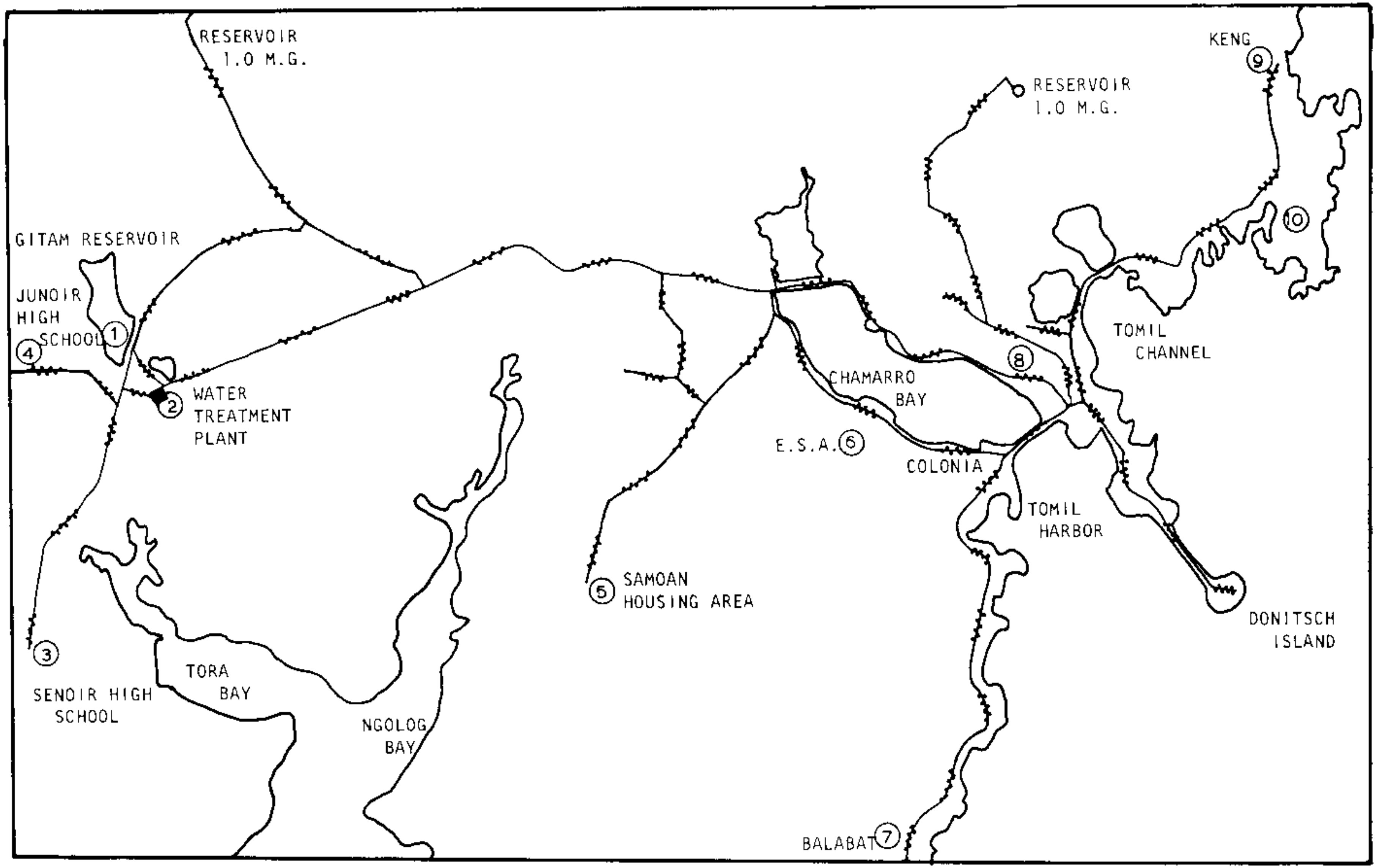


Figure 2. Water distribution system, Colonia (Yap) municipal public water system.

9. Keng (end of line)

10. New Hospital (Laboratory at Sanitation office)

The population served by the PWS was estimated to be 2700 (Yap District Planning Office); therefore, it is recommended that Total Coliform analyses should be performed at least three times per month (Table 2).

Due to constraints of manpower, time and funding, the minimum recommended PWS Monitoring Program for Koror and Colonia is:

1. Environmental Laboratory

   a. Daily Free Residual Chlorine (FRC) measurements (DPD technique).

2. Distribution System (11 proposed sites - Koror; 10 proposed sites - Colonia)

   a. At Least Twice/Month

      1) Total Coliform, FRC, Turbidity

      2) pH, Temperature

      3) Specific Conductance - If Meter Available

   b. At Least Twice/Week - During Weeks When the PWS Is Not Sampled For Total Coliform.

      1) FRC

This general PWS monitoring program can be applied to the other districts of the TTPI. Specific sample site locations should be checked by the EPB.

Marine Water Quality

The second highest priority monitoring scheme for the TTPI covers the marine environment surrounding the district centers. The Office of Water Research and Technology (OWRT) has funded a study: "The Influence of Modern Water Supply and Wastewater Treatment Systems on Water Quality in Micronesia, Phase I ". This study, to be performed in June (Colonia area of Yap) and July (Koror area of Palau) of 1980, will evaluate marine water quality over a 30 consecutive day period in each of these district centers. Subsequent funding (Phase II, FY 1981) will allow expansion of the study to other district centers of the TTPI. In addition to gathering baseline data, it is the intent of these projects to further train local environmental specialists in marine water quality sampling and analytical techniques; the local personnel will than be capable of monitoring marine water quality so that changes attributed to improved water and wastewater systems can be quantified. The sample points selected in the Colonia and Koror areas (Phase I) will serve as a basis for the proposed TTPI marine water quality monitoring strategy.

Marine water quality site locations for the Koror municipality are represented in Figure 3. Sample site descriptions for these sites as well as Fecal Coliform data for the period from July 1978 to February 1980 are presented in Table 3. Sample site selection for Koror (Palau) and Colonia (Yap) included those sites outlined in a recent task force report (TTPI, 1979).

Marine sample sites for the Colonia area of Yap include:

1. Tora Bay - below high school leach field
2. off Madrich - first small bay below public works
3. Donitsch STP Outfall
4. Chamarro Bay off ESA Hotel
5. Chamarro Bay near Causeway Store
6. Chamarro Bay off Rai View Hotel
7. Tomil Harbor
8. Tomil Channel off Yap Co-op Association (YCA)
9. Tomil Channel off laundromat
10. off Tabenemuth

These sites are represented in Figure 4.

Recommended sampling frequencies for marine water quality monitoring programs for the TTPI (as set forth in the Koror and Colonia strategies) are:

1. At Least Twice/Month

    a. Fecal Coliform (FC), Free Residual Chlorine (FRC) and Turbidity

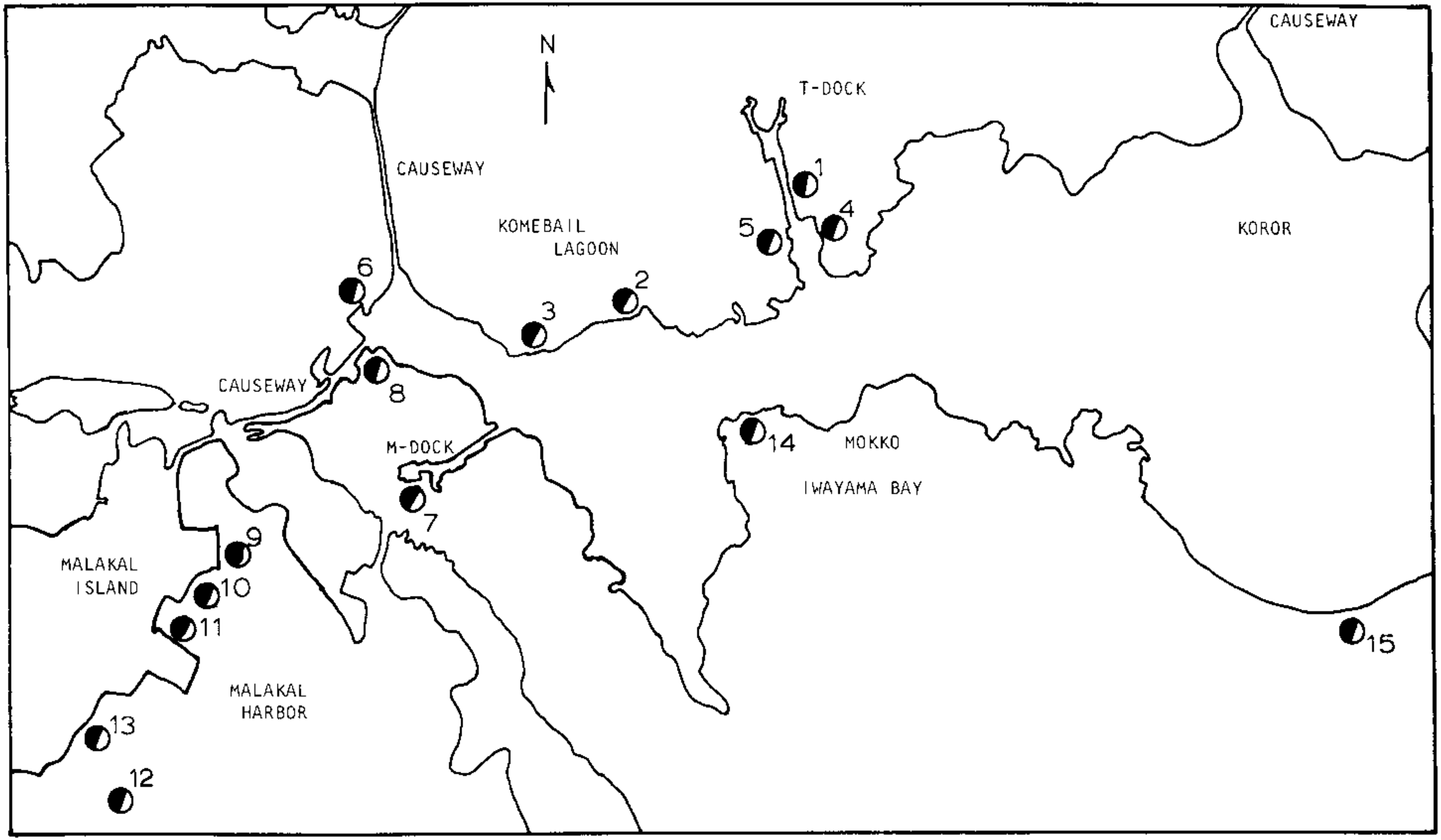


Figure 3. Marine water quality sampling sites - Koror, Palau.

Table 3. Fecal Coliform (#/100 mℓ) data for Koror, Palau (July, 1978 - February, 1980).

Number	Sample Site Description	1978 July 12	1978 July 19	1978 Aug 23	1978 Sept 28	1979 Jan 18	1979 Feb 14	1979 Aug 14	1979 Aug 17	1979 Dec 20,21	1980 Feb 4	1980 Feb 5
1	T-Dock, east side									18	61	
-	T-Dock, swimming pool				20			5	0			0
-	T-Dock, north side	TNTC	193	TNTC					6			8
-	Renrak Bridge									2	0	
-	Airai					3						
-	Blue Lagoon Hotel					53						
2	MOC									0	6	
3	Palau High School											
-	East of Arakabesan Is.									1	0	
4	DNT Hotel			TNTC		TNTC		186				
5	Kyosha Anderson Dock			TNTC		TNTC		192				
6	Metal Bai	98	40	245				103				82
-	Meyuns									2	126	
-	Cave Inn	26	6				9	3				3
-	Peleliu Club			112				85				98
-	North of Ngarol Is.									0	0	
-	Ngardis									0	0	
7	M-Dock	18	4				27					28
8	Community Club	148	80	123		215		215				198
-	Caroline Fishery	18	5									21
9	Micronesian Industrial Corp.							9				
10	Malakal Fishery	22	8				14	18	12		12	18
11	East of Van Camp						8		TNTC	0		
-	Malakal Harbor				9							
-	South Tip Malakal				8							
-	Mariculture				112							120
12	STP Outfall				6						0	
13	STP Shore	5	3									
-	North of Malakal	3	0									
14	Iwayama Bay									0	56	
-	Iwayama Bay									0	0	
15	Iwayama Bay									0	3	
-	Iwayama Bay									0	0	
-	North of Arakabesan						12			0	0	

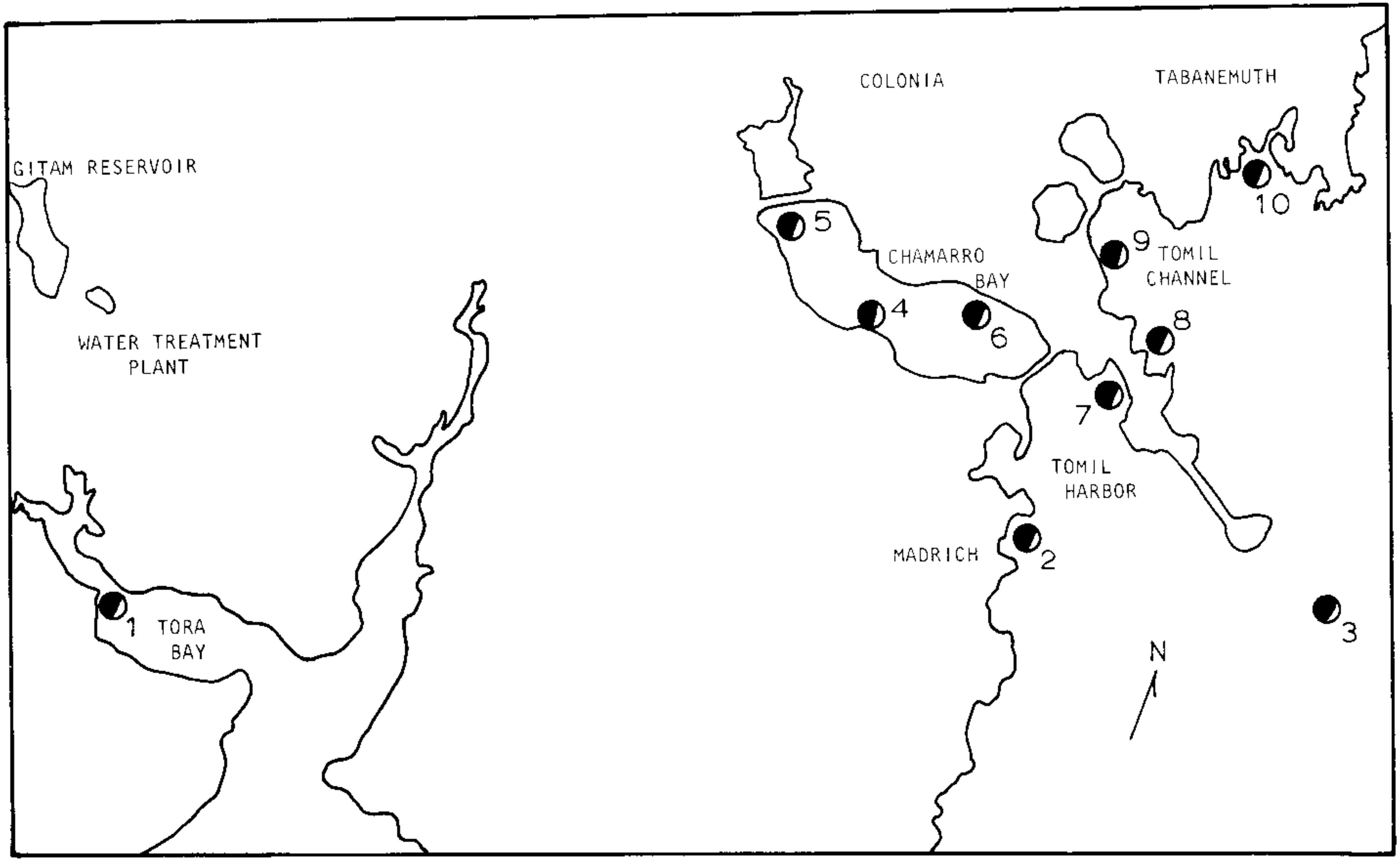


Figure 4. Marine water quality sampling sites - Colonia, Yap.

b. pH, Temperature

c. Total Coliform (TC)

d. Dissolved Oxygen

e. Salinity

National Pollutant Discharge Elimination System Permit

Satisfactory fulfillment of the NPDES Permit monitoring requirements can only be accomplished when local personnel have received further, more extensive training in general laboratory operations and procedures. Based upon the author's knowledge of the operations in Koror and Colonia, specific training must include:

i. Laboratory Chemical Reagent Preparation Techniques

ii. Dissolved Oxygen Analysis

iii. Biochemical Oxygen Demand Analysis

iv. Suspended Solids Analysis

v. Settleable Matter Analysis

Future expenses relevant to these analyses include the purchasing of appropriate equipment, chemicals and supplies (see Appendix A). Prioritization of these analytical techniques along with proposed sampling frequencies are listed in the Summary and Recommendations Section.

DATA ANALYSIS AND REPORTING PROCEDURES

District Sanitation Officers should maintain bacteriological records for at least 5 years and chemical - physical records for at least 10 years; these are minimum periods (TTPI, 1978). The Area and/or District Sanitarian should maintain a file of all reports submitted to the EPB concerning water quality analysis.

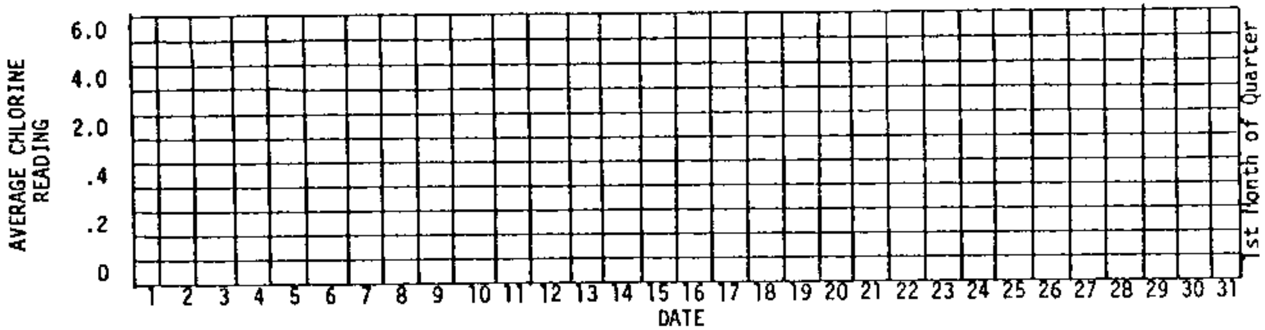
Water Quality Data Records

Data sheets should contain the following information (TTPI, 1978):

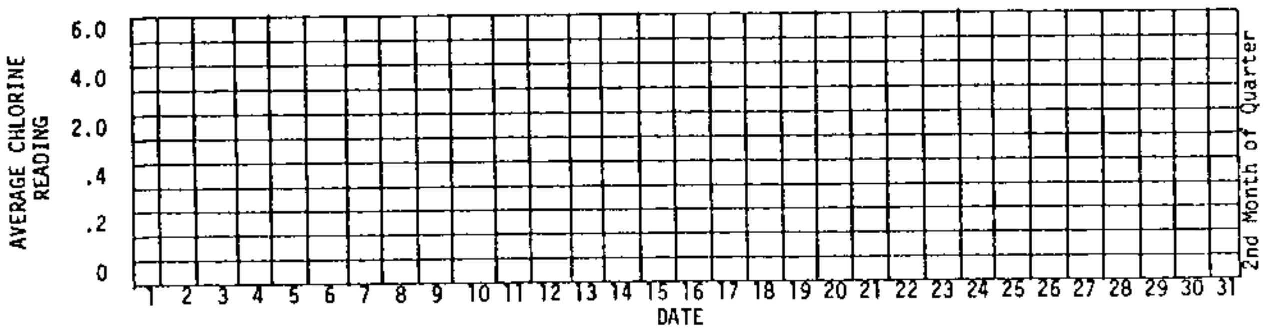
i. Date, place, time of sampling and name of person sampling

Table 5. Daily free residual chlorine data sheet- environmental laboratory.

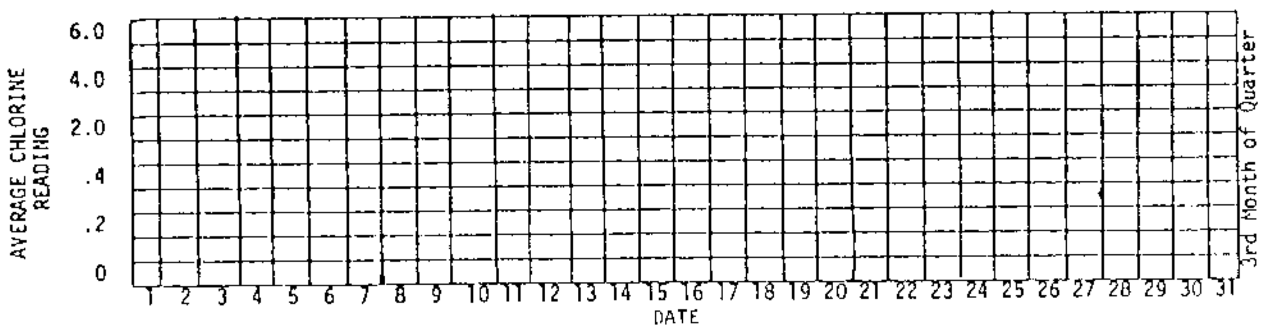
NAME OF SYSTEM ____________



NAME OF SYSTEM ____________



NAME OF SYSTEM ____________



____
DATE

____
CHIEF DISTRICT SANITARIAN

Table 6. Marine water quality monitoring data sheet.

Area Sanitation Laboratory
Macdonald Memorial Hospital
Koror, Palau W. C. I. 96940

Sample/Analysis Date:__________ Sample Collector:__________
Environmental Specialist:__________

SITE		Sample	Free Res. Cl_2	Turbidity	pH	Temperature	Salinity	Dissolved Oxygen	FECAL COLIFORM				TOTAL COLIFORM				Comments*
Number	Description								Aliquot	Colonies	FC	Analysis	Aliquot	Colonies	TC	Analysis	
			mg/ℓ	TU	°C	°/oo	mg/ℓ	mℓ	#	#/100 mℓ	Time	mℓ	#	#/100 mℓ	Time		

*Comments include observations
I Field – distance from shore; surface or depth sample; presence of floating material; tides; etc.
II Laboratory – unusual occurrences; water bath or incubator temperature variances; problems in analytical techniques; etc.

iv. Delays in analysis of samples;

v. Excessive colony growth resulting from not making the correct dilution.

Water Quality Standard Reporting Procedures - Public Water Systems

Total Coliform (TC), Turbidity and Free Residual Chlorine (FRC) standards for PWS (APHA, 1975; Young et al., 1977; TTPI, 1978) are summarized below. Utilizing the membrane filter (MF) technique, the number of Total Coliform (TC) shall not exceed:

i. 1 TC/100 mℓ as the arithmetic mean of all samples examined per month;

ii. 4 TC/100 mℓ in more than 1 sample when less than 20 samples are examined per month;

iii. 4 TC/100 mℓ in more than 5% of the samples if 20 or more samples are examined per month.

If the Total Coliform concentration in a single sample exceeds 4/100 mℓ, at least 2 consecutive daily samples must be collected from the same sampling point. It is recommended that additional samples be taken until the results obtained from 2 consecutive samples show TC to be less than 1 TC/100 mℓ. THE RESULTS OF THESE ANALYSES SHOULD BE REPORTED TO THE EPB WITHIN 48 HOURS.

Turbidity values, as determined by monthly averages, should not exceed 1 turbidity unit (TU). If the monthly average exceeds 1 TU or if 2 consecutive samples exceed 5 TU, the local Environmental Specialist MUST REPORT THESE RESULTS TO THE EPB WITHIN 48 HOURS.

A minimum value of 0.2 mg/ℓ Free Residual Chlorine (FRC) must be maintained in any PWS. If FRC is less than 0.2 mg/ℓ, the Environmental Specialist should re-check the water within 1 hour. If the low FRC value (<0.2 mg/ℓ) is confirmed in this second sample, a Total Coliform analysis must be performed on the water. RESULTS OF BOTH LOW FRC VALUES AND THE SUBSEQUENT TOTAL COLIFORM ANALYSIS MUST BE REPORTED TO THE EPB WITHIN 48 HOURS.

Water Quality Standards Reporting Procedures - Marine Waters

Marine water quality standards are grouped according to TTPI coastal water classifications (Table 7). Pertinent marine water quality standards are presented in Table 8; these values are standards proposed by Cowan and Clayshulte (1980) based upon a recent marine baseline water quality study of the TTPI.

The proposed monitoring strategy for marine waters outlines a minimum of 2 samples per month be taken at representative sites surrounding the district centers. The results from this monitoring program should be reported to the EPB each month.

Table 7. 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, commercial 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 8. Proposed marine water quality standards for the Trust Territory of the Pacific Islands.

<table>
<tr><th>PARAMETER</th><th>UNITS</th><th>CLASS AA</th><th>CLASS A</th><th>CLASS B</th></tr>
<tr><td>Total Coliform</td><td>#/100 mℓ</td><td><230</td><td></td><td></td></tr>
<tr><td>Fecal Coliform</td><td>#/100 mℓ</td><td></td><td><400</td><td><400</td></tr>
<tr><td>pH</td><td></td><td colspan="3">--------[6.5 ≤ pH ≤ 8.5]----------</td></tr>
<tr><td></td><td></td><td colspan="3">----------[8.10±0.40]------------</td></tr>
<tr><td>Turbidity</td><td>NTU</td><td>≤1.0</td><td>≤1.0</td><td>≤2.0</td></tr>
<tr><td>Temperature</td><td>°C</td><td colspan="3">-----------[29.0±1.5]------------</td></tr>
<tr><td>Salinity</td><td>°/oo</td><td colspan="3">------------[32±3]---------------</td></tr>
<tr><td>Dissolved Oxygen</td><td>mg/ℓ</td><td>≥6.0 or 75% of saturation, which ever is greater</td><td>≥5.0</td><td>≥4.5</td></tr>
</table>

Equipment, supplies, costs: General Laboratory Requirements.

Equipment	Estimated Price
1. Water Demineralizer - Model LD2A	$400
Ultra High Purity Cartridges (order at least 6)	240
Note: High quality reagent grade water is needed in any analytical laboratory. If distilled water is available at local laboratory (hospital), this demineralizer need not be purchased.	
2. Triple Beam Balance Ohaus Model 710 2610 grams capacity ± 0.1 gram	100
3. Mechanical Analytical Balance - Sartorius Model 2842 SR 160 grams maximum ± 0.1 milligram Note: This balance is required for measuring chemicals for reagent preparation at sensitivity levels < 0.1 gram and for suspended solids (SS), volatile suspended solids (VSS) determinations.	1800
4. Drying Oven - Blue M Model OV-490A-2	820
5. Hot Plate - Corning Model PC 35	70
6. Magnetic Stirrer	100
7. Refrigerator-Freezer, 14 cubic foot	950
Sub Total	$4480

Supplies

1. Ice chest (48 quart) 2 * $50/each	$100
2. Sample Bottles, Linear Polyethylene	
wide mouth (1ℓ) 2 * $45/(case of 24)	90
(500mℓ) $45/(case of 48)	45
3. Reagent Bottles, Pyrex (1ℓ) $70/(pack of 12)	70
4. Lab scoop 4 * $2.50	10
Spoon Micro Saptula 4 * $3	12
5. Detergent (1·2·2, No phosphate) 2 * 4 lb $10 each	20
6. Kimwipes 5" * 8 3/8" $45/case	45
7. Parafilm (4")	15

8.	Stirring Bar Retriever	$10
	Stirring Bars - one set	30
9.	Weighing Paper	3
	Weighing Boats 41 * 41 * 8 mm Box of 500	10
	81 * 81 * 22 mm Box of 500	15
10.	Graduated Cylinder, Pyrex 50 mℓ 3 * $7 each	21
	100 mℓ 4 * $9 each	36
	500 mℓ 2 * $15 each	30
	1000 mℓ 2 * $20 each	40
11.	Polyethylene Washing Bottles (500mℓ) $10/(pack of 6)	10
12.	Autoclavable Car Boy with Spigot (10ℓ) 2* $35 each	70
13.	Pipette Cleaning Set (for 24" pipette length)	150
14.	Volumetric flasks, Pyrex 50 mℓ $35/(pack of 6)	35
	100 mℓ $40/(pack of 6)	40
	500 mℓ $25/(pack of 2)	25
	1000 mℓ 3 * $12 each	36
15.	Brush, Test Tube - Bristle 4½" * 1 3/4" approximately, $12/dozen	12
16.	Safety Equipment	
	Lab coats 2 * $20 each	40
	Protective glasses 2 * $7 each	14
	Portable Eye Wash	90
	First Aid Kit (Laboratory)	30
	Safety Pipet Filler 5 * $15	75
	Sub Total	$1229
	Estimated Total Cost	$5709

Equipment, chemicals, supplies, costs: Total and Fecal Coliform.

Equipment	Estimated Price
1. Incubator - Imperial II, Lab-Line, 3 shelves, type (Total Coliform)	$900
2. Incubator - Precision Model 66850 Water bath type, circulating (Fecal Coliform)	750
Cover (Required)	120
3. Vacuum Pump - Doerr 1/6 H.P. (0-20 psi)	250
Vacuum hose - 4 feet	15
4. Autoclave (Sterilizer) - Model 7 Ritter Speed Clave	850
5. Comparator (Chlorine Residual, Total and Free, DPD) Hellige	175
DPD Pillows 20 * $5/(pack of 50) Free Residual Chlorine	100
Sub Total	3160

Chemicals (Reagent Grade)	
1. M-Endo Broth MF (Total Coliform) 2 * ¼lb, $10 each	20
Ethanol (95%) obtain at local hospital 500 mℓ	10
or	
MF-Endo Broth Medium, 2 mℓ ampoules 40 * $20/(pack of 24)	[800]
2. M-FC Broth (Fecal Coliform) 2 * ¼lb, $10 each	20
Rosolic Acid 100 grams	30
or	
M-FC Broth Medium, 2 mℓ ampoules 40 * $20/(pack of 24)	[800]
3. Monobasic Potassium Phosphate (KH_2PO_4) 1 lb	15
4. Propanol 1ℓ	2
5. Magnesium Sulfate ($MgSO_4 \cdot 7H_2O$) 2 * $15/lb	30
6. Sodium Hydroxide (NaOH) 1 lb	5
7. Sodium Thiosulfate ($Na_2S_2O_3$) 1 lb	12
Sub Total (with Broth)	$144
Sub Total (with ampoules)	$1664

Supplies

1.	Millipore Filtration Apparatus 3 * $150/set		$450
	Vacuum Filtering Flask, 1ℓ . cat. no.	XX1004705	
	Funnel, 300 mℓ , Teflon Faced	XX1004724	
	Teflon Faced Base w/stopper	XX1004722	
	Clamp	XX1004703	
	Forceps, Stainless, Smooth-Tip	XX6200006	
2.	Millipore S-Pak Filter Kit, Type HA cat. no. HAWG04752		
	2 * $300/kit		600
	Dispenser		
	47mm Filter Pads, Sterile (1000)		
	47 mm 0.45 μ Filters, Sterile (1000)		
3.	Petri Dishes, Sterile 2 * $200/(1000 dishes)		400
4.	Sterilizer Forceps 2 * $8 each		16
5.	Whirl-Pak Bags (18 oz), Sterile 4 * $40/(pack of 500)		160
6.	Alcohol-Lamp 2* $15 each		30
7.	Sample Bottles, Screw Cap (160 mℓ) $50/(case of 48)		50
8.	Dilution Bottles, Screw cap (99 mℓ graduation line) $25/dozen		25
9.	Pipettes, Pyrex (1mℓ) 2 * $40/(case of 18)		80
	(10mℓ) 2 * $50/(case of 18)		100
10.	Pipette Canisters 4 * $15/each		60
11.	Beakers, Pyrex 1000 mℓ 3 @ $25 each		75
	500 mℓ 3 @ $15 each		45
12.	Magnifier (4") 2 * $12 each		24
13.	Aluminium Foil		2
		Sub Total	$2117
		Estimated Total Cost (with Broth)	$5421
		Estimated Total Cost (with ampoules)	$6941

Equipment, supplies, costs: pH.

Equipment	Estimated Price
1. Orion Specific Ion Meter Model 407 A/L	$700
Reasons for Purchase: 1) Sturdy Construction 2) Can be Operated with Field-Batteries or on Line Power (cord included) 3) Carrying Case Included 4) Can be used with Specific Ion Probes to Measure Other Parameters (e.g., Cl)	
Sub Total	$700

Supplies	
1. Probes - Orion 91-05 Series-gel filled	
Reasons for Purchase: Combination type-gel filled relieves requirement for filling solution. Purchase 2 per meter at $36 each	$72
2. pH Buffer Solutions - Buffer Tablets for range 6, 7 and 8 2 packs of 5 each $8/pack	48
3. Plastic beakers 100 mℓ $40/(case of 36)	40
4. Mercury Thermometer to measure sample and buffer temperatures prior of pH meter calibration. Need temperature range 20-50 °C $\pm$ 0.1 °C 3 * $20 each	60
5. Thermometer Guard - Brass for protection of thermometer from breakage	7
Sub Total	$227
Estimated Total Cost	$927

Equipment, chemicals, costs: Turbidity and Specific Conductance			Estimated Price

Turbidity

Equipment

1. Turbidimeter - Hach Model 16800		Estimated Total Cost	$650

Specific Conductance

Equipment

1. Lectro Mho-Meter (MC3) - Lab-Line (11025)			$450

Chemicals

1. Potassium Chloride (KCl)	1 lb		$7
		Estimated Total Cost	$457

Equipment, chemicals, supplies, costs: Dissolved Oxygen

Equipment	Estimated Price
1. Magnetic Stirrer - (see General Laboratory Requirements)	*

Chemical (Reagent Grade)

1. Soluble Starch ½ lb	$10
2. Manganous Sulfate ($MnSO_4 \cdot H_2O$) 5 lb	50
3. Sodium Azide (NaN_3) 100 grams	50
4. Sodium Hydroxide (NaOH) 5 lb	20
5. Sodium Iodide (NaI) 2 lb	90
6. Sodium Thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) 1 lb	12
7. Potassium Dichromate, Primary Standard ($K_2Cr_2O_7$) 1 lb	15
8. Potassium Iodide (KI) 1 lb	45
9. Sulfuric Acid (concentrated) 4 * $5/pint	20
10. Salicylic Acid 1 lb	10
Sub Total	$322

Supplies

1. D.O. Bottles (300 mℓ capacity) 2 * $100/(case of 20)	$200
2. Polythylene Caps (100 per pack)	60
3. Rack for D. O. Bottle 2 * $30 each	60
4. Automatic Pipettes 6 * $17 each	102
Pipette tubes $60/(case of 24)	60
Pipette bulbs 20 * $2 each	40
5. Buret - 50 mℓ capacity, 0.1 mℓ divisions $75/(case of 2)	75
6. Buret Support (small) and Clamp (Double) $10 + $12	22
7. Mortar (45 mℓ capacity), Pestle (Porcelain) 1 each	8
8. Erlenmeyer Flasks, wide mouth (500 mℓ) $25/(pack of 6)	25

9.	Volumetric Flasks, Polypropylene (graduation line at 203 mℓ) 2 * $9 each	$18
10.	Volumetric Pipettes, Pyrex (20 mℓ) 4 * $5 each	20
	Sub Total	$690
	Estimated Total Cost	$1012

Equipment, chemicals, supplies, costs: Biochemical Oxygen Demand

Equipment	Estimated Price
1. Magnetic Stirrer (see General Laboratory Requirements)	*
2. Incubator (BOD) - Revco. IR 1705. 17 cubic foot 5°-45°C	$1200
Sub Total	$1200

Chemicals (Reagent Grade)	
1. Monobasic Potassium Phosphate (KH_2PO_4) 1 lb	$15
2. Dibasic Potassium Phosphate (K_2HPO_4) 1 lb	15
3. Dibasic Sodium Phosphate ($Na_2HPO_4 \cdot 12\ H_2O$) 1 lb	10
4. Ammonium Chloride (NH_4Cl) 1 lb	8
5. Magnesium Sulfate ($MgSO_4 \cdot 7H_2O$) 1 lb	15
6. Calcium Chloride ($CaCl_2$) 1 lb	12
7. Ferric Chloride ($FeCl_3 \cdot 6H_2O$) 1 lb	15
8. Sodium Sulfite (Na_2SO_3) 1 lb	6
9. Sodium Hydroxide 1 lb	5
10. Sulfuric Acid 4 * $5/pint	20
11. Potassium Iodide 1 lb	45
12. See chemicals: Dissolved Oxygen	*
Sub total	$166

Supplies	
See Dissolved Oxygen	*
Estimated Total Cost	$1366

Equipment, supplies, costs: Suspended Solids, Volatile Suspended Solids and Settleable Matter

Equipment	Estimated Price
1. Oven, Mechanical Convection, Utility - Drying Oven (see General Laboratory Requirements)	*
2. Furnace, Muffle, Type 1400 - Thermolyne F-B1415M (0-1200°C)	$300
3. Vacuum Pump, Vacuum Hose (see Total and Fecal Coliform)	*
4. Mechanical Analytical Balance - (see General Laboratory Requirements)	*
Sub Total	$300

Supplies	
1. Filter Paper, Glass Microfiber, Whatman, Grade GF/C 4.25 cm 5 * $8/(pack of 100)	$40
2. Filtration Apparatus - (see Total and Fecal Coliform)	*
3. Beakers, Pyrex (2ℓ capacity) $25/(pack of 4)	25
Sub Total	$65
Estimated Total Cost	$365

Equipment, costs: Salinity	Estimated Price
1. American optical temperature compensated refractometer with salinity scale, can be read $\pm$ 0.5 $^{o}/oo$.	$480

Reasons for Purchase:

1) Readily Portable
2) Low Maintenance Requirements
3) No Parts Requiring Periodic Replacement

2. Requires calibration with Standard Seawater obtained from:

I.A.P.S.O. Standard Seawater Service Charlottenlund Slot 2920 Charlottenlund, Denmark — no charge

Calibrate every 6 months - 1 year

Note: Calibration requires access using jewelers size screwdriver (can be ordered from photography supplies catalogue).

Estimated Total Cost $480

Supply Companies and Equipment Manufacturers

1. CMS
   2660 Wai Wai Loop
   Honolulu, HI 96919 Delivery Time: 4-12 weeks

2. Millipore Intertech, Inc.
   P. O. Box 255
   Bedford, Mass. 01730, USA

3. J.T. Baker Chemical Co.
   995 Zephr Avenue
   Hayward, CA 94544

4. Markson Science, Inc.
   P. O. Box 767
   Del Mar, CA 92014

5. A.A.A.S (American Association for the Advancement of Science)
   1515 Mass. Avenue, N.W.
   Washington, D. C. 20005

   Note: Request - "Guide to Scientific Instruments".
   Contains information on suppliers of equipment, supplies and chemicals.

APPENDIX B

METHODOLOGY FOR WATER QUALITY ANALYSES

TOTAL COLIFORM

(Membrane Filter Technique)*

A. GENERAL

1. Reference: *Standard Methods* (1975) pp. 928-935.

2. Outline and Method: Sample is obtained in a sterile bottle or plastic bag and is filtered through a sterile 0.45 μ Millipore filter, which is placed on a sterile pad saturated with liquid media. The filter is then incubated at 35 ± 0.5 °C for 22-24 hours. If Drinking Water Standard is required, an enrichment step can be included; however, the enrichment step need not be performed when repeated determinations have shown adequate results are obtained by the single step technique.

B. MATERIALS AND CULTURE MEDIA

1. Sample Bottles: Pyrex glass wide mouth bottle with rubber lined cap, approx. 125 mℓ capacity. Whirl-Pak bags (sterile) are acceptable. For large filtration volumes, any screw cap bottle capable of being sterilized is acceptable.

2. Petri Dishes: Approximately 50 mm diameter, disposal plastic, sterile, tight sealing. 90 percent relative humidity must be maintained inside the dish. Humidity may be maintained by incubation in any container in which the atmosphere is saturated with water.

3. Pipets and Pipet Containers: Pipets can be wrapped in paper for sterilization when aluminum or stainless steel containers are not available. Bacteriological-Serological graduated 1 and 10 mℓ pipets are recommended.

4. Graduate Cylinders: Pyrex glass, 100 mℓ capacity.

5. Incubator: Cabinet type, capable of maintaining 35 °C ± 0.5°C.

6. Filtration Apparatus: Standard Millipore filter holder assembly.

7. Membrane Filters: 0.45 μ, Millipore Corp., Sterile.

8. Absorbent Pads: Millipore Corp., sterile.

9. Forceps: Nonserated with round or blunt tips.

10. Microscope: A binocular wide field dissecting scope; a small fluorescent lamp with magnifier is acceptable. Optical system with an incandescent light source is unsatisfactory.

*Other methods exist for testing bacteriological water quality (Standard Methods, 1975). The membrane filter technique is the least time consuming and most widely used technique.

11. Vaccum Source: Vacuum pump capable of producing suction of 15-20 psi.

12. Comparator: Colorimetric DPD free residual chlorine kit.

13. Culture Media: M-Endo Broth MF.+ Dissolve 4.8 g in 100 mℓ distilled water which contains 2 mℓ of ethanol. Heat to boiling. Don't prolong boiling or heat in autoclave. Cool to room temperature, covered with foil. Store in dark at 2-10°C and any unused media discharded after 96 hr.

14. 1 N Sodium Hydroxide Solution: Dissolved 40 g NaOH in distilled water and dilute to 1 ℓ.

15. Phosphate Buffer Stock: Dissolve 34.0 g KH_2PO_4 in 500 mℓ distilled water, adjust pH to 7.2 with 1 N NaOH and dilute to 1 liter with distilled water. Store stock solution in a refrigerator.

16. Magnesium Sulfate Solution: Dissolve 50 g $MgSO_4 \cdot 7H_2O$ in distilled water and dilute to 1 ℓ. Store solution in a refrigerator.

17. Dilution Water: Add 1.25 mℓ phosphate buffer stock and 5.0 mℓ magnesium sulfate solution to 1 liter distilled water. Sterilize by autoclaving for 15 min. at 121°C (15-17 psi).

18. 10% Sodium Thiosulfate Solution: Dissolve 10 g $Na_2S_2O_3$ in distilled water and dilute to 100 mℓ. Store solution in a refrigerator.

19. Sterilization: Sample bottles, filtration units, graduated cylinders, pipettes and containers are sterilized in an autoclave at 121°C (15-17 psi) for 15 min. Sample bottle caps should be loose fitting; close cap tightly after bottles have cooled to room temperature. Graduated cylinders should be covered (foil) prior to sterilization. Dilution water may be sterilized at the same time.

    CAUTION: Always use slow exhaust when liquids are included in the material to be sterilized in the autoclave.

20. Sampling: Collect sample in a sterile bottle such that water doesn't flow across hand and into the bottle. In a moving stream, point opening of bottle upstream and sweep bottle through water against the current, again, so there is not hand contamination. If sampling from a water distribution system, fully open tap (2 min) in order to clear water line; restrict flow to permit filling of the sample bottle without splashing.

+Pre-made media can be purchased from Millipore Corp. in 2 mℓ ampoules.

C. PROCEDURE

A. Alcohol-flame forceps prior to each handling of filters or pads. Touch only the edge of the filters with the forceps.

B. Select sample size (Table 909: I, Standard Methods, 1975, p 932) based upon expected bacterial density, about 50 coliform colonies and not more than 200 colonies of all types. If less than 20 mℓ of sample is filtered, a small amount of sterile dilution water should be added to the funnel before filtration.

1. Place pad in Petri dish bottom (smaller diameter half) and pipet 1.8-2.0 mℓ of M-Endo Broth MF on absorbent pad. (Enough broth to saturate the pad. Excess media may be poured out of the dish.)

2. Dilution Water Blank: Filter 2-100 mℓ aliquots of dilution water in addition to regular samples; these blanks should yield no growth.

3. Place membrane filter in filtration apparatus and filter vigorously shaken sample under partial vacuum. Rinse filter using three 20-30 mℓ portions of sterile dilution water.

   NOTE: Use one sterile filtration apparatus for each sample (dilution series of the same sample).
   Dilution series: filter in order from highest dilution (smallest amount of sample) to lowest dilution (greatest amount of sample).

4. Remove membrane filter from filtration unit and roll it on the pad avoiding any entrapment of air.

5. Resterilize filter holder assembly (funnel and filter base) between each sample (dilution series of sample). Place assembly in boiling distilled water for 1 minute; cool assembly to room temperature before reusing.

6. Incubate the dish, inverted, for 22-24 hrs. at 35 ± 0.5°C.

7. Count typical coliform colonies, those which have a pink to dark red color with a golden-green metallic surface sheen.

8. Compute coliform densities from the membrane filter count within the 20-80 coliform colony range.

D. CALCULATION:

$$\text{TOTAL COLIFORM/100 m}\ell = \frac{\text{COLIFORM COLONIES COUNTED X 100}}{\text{m}\ell\text{ sample filtered}}$$

Table 909: I. Suggested Sample Volumes for Membrane Filter Total Coliform Test

Water Source	Volume to be Filtered, mℓ							
	100	50	10	1	0.1	0.01	0.001	0.0001
Drinking water	X							
Swimming pools	X							
Wells, springs	X	X	X					
Lakes, reservoirs	X	X	X					
Water supply intake			X	X	X			
Bathing beaches			X	X	X			
River water			X	X	X	X		
Chlorinated sewage			X	X	X			
Raw sewage					X	X	X	X

Table 909: II. 95% Confidence Limits for Membrane Filter Results Using a 100 mℓ Sample.

Number of Coliform Colonies Counted	95% Confidence Limits	
	Lower	Upper
1	0.05	3.0
2	0.35	4.7
3	0.81	6.3
4	1.4	7.7
5	2.0	9.2

E. NOTES:

1. Sterilization of all equipment is essential. Buy sterile plastic Petri dishes.

2. After tests have been completed, disposable Petri dishes are autoclaved at 121° C (15-17 psi) for 15 min. This will destroy the dish (melts) and any bacteria present. Remains may then be thrown away.

3. If confluent growth occurs (growth covering filter with no discrete colonies) report results as "confluent growth".

4. If the total number of bacterial colonies (coliforms and non-coliforms) exceeds 200 per membrane or if the colonies are too indistinct to count, report results as TNTC (Too Numerous To Count).

5. Statistical reliability of membrane filter results are listed in Table 909:II (Standard Methods, 1975, p 935).

6. Dechlorination

   a. Use a comparator test kit to determine the present of free residual chlorine.

   b. Sodium thiosulfate (dechlorinating agent) is added to sample bottles when collecting water containing residual chlorine.

   c. Add 0.1 mℓ of a 10% $Na_2S_2O_3$ solution to a 120 mℓ (4 oz.) sample bottle; this will neutralize a sample containing 15 mg/ℓ residual chlorine. The bottle is loosely capped and sterilized in an autoclave at 121° C (15-17 psi) for 15 min. Sample bottle cap should be closed tightly after bottle is cooled to room temperature.

7. Samples must be stored in an insulated ice chest during transportation to the laboratory. Total Coliform analyses should be performed within 4-6 hours (freshwater) or 4 hours (marine water).

FECAL COLIFORM

(Membrane Filter Technique)

A. GENERAL

1. Reference: *Standard Methods* (1975) pp. 937-939.

2. Outline of Method: Samples are collected and filtered through a 0.45 μ Millipore filter which is cultured on an M-FC saturated pad for 24 hrs. at 44.5 ± 0.2° C. This procedure yields 93 percent accuracy for culturing coliform bacteria which originate in warm-blooded animals; method selectivity is due to the high incubation temperature.

B. MATERIALS AND CULTURE MEDIA

1. Sample bottles, Petri dishes, Whirl-Pak bags, See Total Coliform.

2. Water Bath: Stirring water bath capable of 44.5 ± 0.2° C temperature tolerance.

3. 0.2 N Sodium Hydroxide Solution: Dissolve 8 g NaOH in distilled water and dilute to 1 ℓ.

4. 1% Rosalic Acid Solution: Dissolve 1 g Rosalic Acid in 100 mℓ of 0.2N NaOH.

   NOTE: The 1% Rosolic Acid solution should be stored in the dark at 1-10° C and disgarded after 2 weeks (or sooner if its color changes from dark red to muddy brown).

5. M-FC Broth*: Dissolve 3.7 g of broth in 100 mℓ distilled water. Add 1.0 mℓ of 1% Rosolic Acid solution. Heat to boiling, promptly remove from heat and cool to below 45° C. DO NOT AUTOCLAVE. Media can be stored at 1-10° C and unused portion must be discarded 96 hrs. after preparation.

6. Filtration Set-up, 0.45 μ membrane filters, pads, graduated cylinders, pipets and pipet containers, dilution water, dechlorinating agent, vacuum source, comparator and forceps: See Total Coliform.

7. Sampled bottles, filtration units, graduated cylinders, pipets and containers are sterilized in an autoclave at 121° C (15-17 psi) for 15 min. Sample bottle caps should be loose fitting; close caps tightly after bottles have cooled to room temperature. Graduated cylinders should be covered (foil) prior to sterilization.

   CAUTION: Always use slow exhaust when liquids are included in the material to be sterilized in the autoclave.

*Pre-made media can be purchased from Millipore Corp. in 2 mℓ ampoules.

8. Sampling: Collect sample in a sterile bottle such that water doesn't flow across hand and into the bottle. In a moving stream, point opening of bottle upstream and sweep bottle through water against the current, again, so there is no hand contamination.

C. PROCEDURE

A. Alcohol-flame forceps prior to each handling of filter or pads. Touch only the edge of the filter with the forceps.

B. Sample size is selected depending upon bacterial densities (Table 909: III, Standard Methods, 1975, p 939). Samples yielding colony counts of between 20 to 60 fecal coliform colonies give highest accuracy. If less than 20 mℓ of sample is filtered, a small amount of sterile dilution water should be added to funnel before filtration.

1. Place absorbent pad in Petri dish and pipet approximately 2 mℓ of M-FC medium to saturate the pad. Excess media may be poured out of the dish.

2. Dilution Water Blank: Filter 2-100 mℓ aliquots of dilution water in addition to regular samples; these blanks should yield no growth.

3. Filter as in Total Coliform.

4. Roll membrane filter on pad being careful to exclude air bubbles. All prepared cultures should be placed in water bath incubator within 30 minutes.

5. Wrap 4 to 6 dishes in a Whirl-Pak bag and anchor below the water surface with dishes inverted and horizontal. (Well below surface to maintain critical temperature requirements)

6. Resterilize filter holder assembly (funnel and filter base) between each sample (dilution series of sample). Place assembly in boiling distilled water for 1 minute: cool assembly to room temperature before reusing.

7. Incubate in water bath for 24 hours at $44.5 \pm 0.2°C$.

8. Count colonies produced by fecal coliform bacteria; they are dark blue in color with rough textured, non-shining surfaces. Nonfecal coliform colonies are blue gray to cream color. Desired fecal coliform range: 20-60 colonies per filter.

D. CALCULATION

$$\text{Fecal Coliform Bacteria/100 m}\ell = \frac{\text{FECAL COLIFORM COLONIES COUNTED} \times 100}{\text{m}\ell \text{ sample filtered}}$$

E. NOTES

1. Sterilization of all equipment is essential. Buy sterile plastic Petri dishes.

2. After tests have been completed, disposable Petri dishes are autoclaved at 121° C (15-17 psi) for 15 min. This will destroy the dish (melts) and any bacteria present. Remains may then be thrown away.

3. Dechlorination

   a. Use a comparator test kit to determine presence of free residual chlorine.

   b. Sodium thiosulfate (dechlorinating agent) is added to sample bottles when collecting water containing residual chlorine.

   c. Add 0.1 mℓ of a 10% $Na_2S_2O_3$ solution to a 120 mℓ (4 oz.) sample bottle; this will neutralize a sample containing 15 mg/ℓ residual chlorine. The bottle is loosely capped and sterilized in an autoclave at 121° C (15-17 psi) for 15 min. Sample bottle cap should be closed tightly after bottle is cooled to room temperature.

4. Samples must be stored in an insulated ice chest during transportation to the laboratory. Fecal Coliform analyses should be performed within 2-4 hours (freshwater) and 2 hours (marine water).

Table 909: III. Suggested Sample Volumes for Membrane Filter Fecal Coliform Test

Water Source	Volume to be Filtered, mℓ						
	100	50	10	1	0.1	0.01	0.001
Lakes, reservoirs	X	X					
Wells, springs	X	X					
Water supply, intake		X	X	X			
Natural bathing water		X	X	X			
Sewage treatment plant, secondary effluent			X	X	X		
Farm ponds, rivers				X	X	X	
Stormwater, runoff				X	X	X	
Raw municpal sewage					X	X	X
Feedlot runoff					X	X	X

SPECIFIC CONDUCTANCE (*EC*)

A. GENERAL

1. Reference: *Standard Methods* (1975) pp. 71-75.

2. Outline of Method: Specific conductance measures the water's capacity to carry an electric current. This property is related to the total concentration of the ionized substances in the water and the temperature at which the measurement is made. Specific conductance is used to monitor the quality of deionized water. The amount of dissolved ionic matter in a sample can be estimated by multiplying the conductivity by some empirical factor.

B. SPECIAL REAGENTS

Standard Potassium Chloride, 0.0100 M: Dissolve 745.6 mg anhydrous KCl in freshly boiled distilled water (DW) and dilute to 1 ℓ. At 25°C, this solution has a specific conductance of 1413 µmhos/cm. Store in glass stoppered pyrex bottle.

C. STANDARDIZATION

Measure temperature and *EC* of standard solution, EC_{std}.

D. PROCEDURE

1. Assemble conductivity meter, rinse the electrode thoroughly with distilled water.

2. Measure temperature and *EC* of samples, EC_{sam}.

E. CALCULATIONS

1. If temperature of the samples and the standard are the same,

$$\text{Specific Conductance} = \frac{1413}{EC_{std}} * EC_{sam}, \mu\text{mhos/cm.}$$

2. If temperatures are different, correct all readings to 25°C (see table next page), and then calculate specific conductance by the above formula.

FACTORS FOR CONVERTING SPECIFIC CONDUCTANCE OF WATER TO EQUIVALENT VALUES AT 25°C.*

$$EC_{25}=EC_t \times f_t$$

°C.	°F.	f_t	°C.	°F.	f_t	°C.	°F.	f_t
3.0	37.4	1.709	22.0	71.6	1.064	29.0	84.2	0.925
4.0	39.2	1.660	22.2	72.0	1.060	29.2	84.6	.921
5.0	41.0	1.613	22.4	72.3	1.055	29.4	84.9	.918
6.0	42.8	1.569	22.6	72.7	1.051	29.6	85.3	.914
7.0	44.6	1.528	22.8	73.0	1.047	29.8	85.6	.911
8.0	46.4	1.488	23.0	73.4	1.043	30.0	86.0	.907
9.0	48.2	1.448	23.2	73.8	1.038	30.2	86.4	.904
10.0	50.0	1.411	23.4	74.1	1.034	30.4	86.7	.901
11.0	51.8	1.375	23.6	74.5	1.029	30.6	87.1	.897
12.0	53.6	1.341	23.8	74.8	1.025	30.8	87.4	.894
13.0	55.4	1.309	24.0	75.2	1.020	31.0	87.8	.890
14.0	57.2	1.277	24.2	75.6	1.016	31.2	88.2	.887
15.0	59.0	1.247	24.4	75.9	1.012	31.4	88.5	.884
16.0	60.8	1.218	24.6	76.3	1.008	31.6	88.9	.880
17.0	62.6	1.189	24.8	76.6	1.004	31.8	89.2	.877
18.0	64.4	1.163	25.0	77.0	1.000	32.0	89.6	.873
18.2	64.8	1.157	25.2	77.4	.996	32.2	90.0	.870
18.4	65.1	1.152	25.4	77.7	.992	32.4	90.3	.867
18.6	65.5	1.147	25.6	78.1	.988	32.6	90.7	.864
18.8	65.8	1.142	25.8	78.5	.983	32.8	91.0	.861
19.0	66.2	1.136	26.0	78.8	.979	33.0	91.4	.858
19.2	66.6	1.131	26.2	79.2	.975	34.0	93.2	.843
19.4	66.9	1.127	26.4	79.5	.971	35.0	95.0	.829
19.6	67.3	1.122	26.6	79.9	.967	36.0	96.8	.815
19.8	67.6	1.117	26.8	80.2	.964	37.0	98.6	.801
20.0	68.0	1.112	27.0	80.6	.960	38.0	100.2	.788
20.2	68.4	1.107	27.2	81.0	.956	39.0	102.2	.775
20.4	68.7	1.102	27.4	81.3	.953	40.0	104.0	.763
20.6	69.1	1.097	27.6	81.7	.950	41.0	105.8	.750
20.8	69.4	1.092	27.8	82.0	.947	42.0	107.6	.739
21.0	69.8	1.087	28.0	82.4	.943	43.0	109.4	.727
21.2	70.2	1.082	28.2	82.8	.940	44.0	111.2	.716
21.4	70.5	1.078	28.4	83.1	.936	45.0	113.0	.705
21.6	70.9	1.073	28.6	83.5	.932	46.0	114.8	.694
21.8	71.2	1.068	28.8	83.8	.929	47.0	116.6	.683

* From Agriculture Handbook 60, U.S.D.A.

DISSOLVED OXYGEN

(Winkler with Azide Modification)

A. GENERAL

1. Reference: *Standard Methods* (1975) pp. 443-449

2. Outline of Method: A divalent manganese solution, followed by a strong alkali, is added to the sample. Any dissolved oxygen rapidly oxidizes an equivalent amount of divalent manganese to basic hydroxides of higher valency states. When the solution is acidified in the presence of iodide, the oxidized manganese again reverts to the divalent state and iodine, equivalent to the original dissolved oxygen content of the water, is liberated. The amount of iodine is then determined by titration with standardized thiosulfate solution.

B. SPECIAL REAGENTS

1. Manganese Sulfate Solution: Dissolve 364 g $MnSO_4 \cdot H_2O$ in distilled water (DW) and dilute to 1 liter; filtration of the reagent may be necessary if dissolution is not complete.

2. Alkali-Iodide-Azide Reagent: Dissolve 500 g of solid NaOH and 135 g NaI (Sodium Iodide) in DW and dilute to 1 liter. Add to this solution, 10 g NaN_3 (Sodium Azide) dissolved in 40 mℓ DW.

3. Conc. Sulfuric Acid: About 36 N H_2SO_4. Hence, 1 mℓ is equivalent to about 3 mℓ of the alkali-iodide-azide reagent.

4. Starch Solution: Prepare an emulsion of starch by grinding 2.5 g of soluble starch and a few mℓ of DW in a mortar. Pour this emulsion into 400 mℓ of boiling DW. Dilute to 500 mℓ. Allow to boil a few minutes; let settle overnight. Use the clear supernate. Store in a plastic squeeze bottle in the refrigerator. Stable 1 month; discard the solution when the endpoint color is no longer pure blue but takes on a green or brown tint. This solution may be preserved with 1.25 g salicylic acid per liter or by the addition of a few drops of toluene.

5. Sodium Thiosulfate Stock Solution, 0.10 N: Dissolve 24.82 g $Na_2S_2O_3 \cdot 5H_2O$ in boiled and cooled distilled water and dilute to 1 liter. Preserve by adding 5 mℓ chloroform or 1 g NaOH per liter.

6. Standard $Na_2S_2O_3$ Titrant, 0.025 N: Dilute 250 mℓ stock to 1 liter; exactly 1 mℓ 0.0250 N is equivalent to 200 μg D.O.

7. Standard Potassium Dichromate, 0.025 N; Dry approximately 2-3 g $K_2Cr_2O_7$ at 103° C for 2 hours and then dissolve 1.226 g of the dried $K_2Cr_2O_7$ in DW and dilute to 1 liter.

8. 1 + 9 H_2SO_4 Solution: Add 10 mℓ conc. H_2SO_4 to 90 mℓ DW.

C. STANDARDIZATION

Thiosulfate Standardization: Dissolve approximately 2 g KI (free of iodate) in 150 mℓ DW in a 500 mℓ Erlenmeyer flask. Add 10 mℓ of 1 + 9 H_2SO_4 solution followed by exactly 20 mℓ of Standard 0.025 N $K_2Cr_2O_7$. Place in dark for 5 min., dilute to approximately 400 mℓ and titrate with 0.025 N thiosulfate solution

$$N \text{ of } N_2S_2O_3 = \frac{(0.025)\ (20)}{m\ell\ \ Na_2S_2O_3 \text{ used}}$$

D. PROCEDURE

1. Rinse a 300 mℓ BOD bottle with sample. Pour the sample into the BOD bottle using a reversing sampler with a length of rubber tubing which extends from the top to the bottom of the bottle. The end of the rubber tube must remain beneath the surface of the water as the bottle is filled. Water is allowed to overflow from the top of the bottle (at least 1/3 of the volume of the bottle should be allowed to overflow). The bottle is then stoppered when all the air bubbles, if any, have been allowed to rise out of the BOD bottle. Temperature of sample should be recorded.

2. Remove the glass stopper and add 2 mℓ of $MnSO_4$ reagent followed by 2 mℓ of the alkali-iodide-azide reagent; introduce both these reagent beneath the surface of the sample. Replace the stopper being careful not to trap air inside. Mix by inverting bottle at least 15 times. Allow floc to settle, shake again. Allow floc to settle again and remove the stopper and immediately add 2 mℓ conc. H_2SO_4 by allowing acid to run down neck of bottle, restopper and mix until the precipitate dissolves leaving a clear yellow orange iodine solution. Dissolution should be complete. Samples stored at this point should be protected from strong sunlight and titrated as soon as possible (within 4 to 8 hrs).

3. Measure 203 mℓ of sample (this corresponds to 200 mℓ of original sample) into a 250 mℓ Erlenmeyer flask (or BOD bottle).

4. Rinse the burette with fresh 0.025 N $Na_2S_2O_3$ and then titrate to a faint yellow color (use a white background). Add 1-2 mℓ of the starch solution and continue the titration until the solution changes from blue to clear.

Note: This titration must not be delayed and the thiosulfate should be added fairly rapidly. Solutions should remain colorless for at least 20 seconds at the endpoint.

Note: Use of the starch solution facilitates clear endpoint detection by forming a blue complex with any iodine remaining in the solution.

5. 1 mℓ of 0.025 N $Na_2S_2O_3$ is equivalent to 200 μg D. O.; therefore, if a 203 mℓ sample (200 mℓ of original sample) is titrated, 1 mℓ 0.025 N $Na_2S_2O_3$ equals 1 mg O_2/ℓ as D.O.

E. CALCULATIONS

$$D.O. = m\ell \text{ of } Na_2S_2O_3 \text{ used} \times \frac{N}{0.025}$$

F. NOTE

The $Na_2S_2O_3$ should be standardized fairly frequently so that appropriate correction of measured D.O. for normality changes can be made.

BIOCHEMICAL OXYGEN DEMAND (BOD)

A. GENERAL

1. Reference: *Standard Methods* (1975) pp. 543-550.

2. Outline of Method: BOD determines the relative oxygen necessary for biological oxidation of wastewaters, effluents, and polluted waters. It is the only test available to determine the amount of oxygen required by bacteria while stablilizing decomposable organic matter. Complete stabilization requires too long an incubation period for practical purposes; therefore, the 5 day period has been accepted as a standard. Samples are incubated in the dark at 20 $\pm$ 1 °C. Dissolved Oxygen levels are measured initially and at the end of the 5 day period using the Winkler with Azide Modification technique.

B. SPECIAL REAGENTS

A. For dilution water

1. Phosphate Buffer Solution: Dissolve 8.5 g KH_2PO_4, 21.75 g K_2HPO_4, 44.6 g $Na_2HPO_4 \cdot 12\ H_2O$, and 1.7 g NH_4Cl in about 500 mℓ of distilled water (DW) and dilute to 1 liter. (33.4 g $Na_2HPO_4 \cdot 7H_2O$).

2. Magnesium Sulfate Solution: Dissolve 22.5 g $MgSO_4 \cdot 7H_2O$ in DW and dilute to 1 liter.

3. Calcium Chloride Solution: Dissolve 27.5 g anhydrous $CaCl_2$ in DW and dilute to 1 liter. (36.4 g $CaCl_2 \cdot 2H_2O$).

4. Ferric Chloride Solution: Dissolve 0.25 g $FeCl_3 \cdot 6H_2O$ in distilled water and dilute to 1 liter.

B. For dechlorination

5. Sodium Sulfite Solution, 0.025 N: Dissolve 1.575 g anhydrous Na_2SO_3 in 1 liter distilled water. Prepare fresh when needed.

6. 1 + 50 H_2SO_4 Solution: Add 1 mℓ conc. H_2SO_4 to 50 mℓ DW.

7. Potassium Iodide (KI) Solution: Dissolve 10 g KI in 100 mℓ DW.

C. For pH adjustment

8. Acid and Alkali Solutions, 1 N: H_2SO_4, NaOH.

D. Dissolved oxygen (see DO section for method and reagents).

C. STANDARDIZATION

See Dissolved Oxygen.

D. PROCEDURE

1. Undiluted Samples: High quality water whose 5 day BOD is less than 7 mg O_2/ℓ. Initial DO should be near saturation levels; if not, aerate sample to saturation. Record initial DO and incubate at 20° C for five days repeating DO procedure.

$$\text{mg } BOD_5/\ell = D_1 - D_2$$

where

D_1 = initial dissolved oxygen

D_2 = 5 day dissolved oxygen

2. Diluted Samples: Because of the limited solubility of oxygen in water, samples with suspected high BOD's must be diluted.

Distilled water is aerated with a supply of clean compressed air. Dilution water should be at 20 ± 1 °C. Add 1 mℓ each of phosphate buffer, magnesium, calcium, and ferric solutions for each liter of dilution water needed. If dilution water is stored, add phosphate buffer just prior to use.

Prepare 2 sets of BOD bottles, including dilution water blanks; one set is for initial and the other set is for the 5 day oxygen determination. Fix one set and incubate the other at 20 °C.

Make several dilution of prepared sample so as to obtain sufficient oxygen depletions.

0.1-1.0%	for strong trade wastes
1-5%	for raw and settled sewage
5-25%	for oxidized effluents
25-100%	for polluted rivers

$$\text{mg } BOD_5/\ell = \frac{(D_1 - D_2) - (B_1 - B_2)}{P}$$

where

B_1 = initial DO of dilution water blank
B_2 = 5 day DO of dilution water blank
P = decimal fraction of sample used

3. Chlorinated Samples: Chlorinated samples are neutralized by sodium sulfite. The appropriate quantity of Na_2SO_3 solution to add to the sample is determined on a 100-1000 mℓ portion of the sample by adding 10 mℓ of a 1 + 50 H_2SO_4 solution, followed by 10 mℓ of a KI solution (10 g in 100 mℓ) and titrating with 0.025 N Na_2SO_3 to the starch-iodide endpoint. Add to a volume of sample the quantity of Na_2SO_3 determined above. Test an aliquot of Na_2SO_3 treated sampled by above method to check for residual chlorine. Use the treated sample for BOD test as in section 5.

4. Caustic Alkaline or Acidic Samples: Neutralize to about pH 7.0 1 N H_2SO_4 or NaOH using a pH meter.

5. Seeding: This procedure is used on neutralized chlorine residuals and other samples which need a biological population capable of oxidizing the organic matter in the wastewater. Standard seed material is settled raw domestic dewage which has been stored at 20 °C for 24-36 hours. Use 2 mℓ per liter of diluted sample (0.2 percent). A seeded blank must be run with samples. A seed correction factor, f, is determined by setting up a separate series of seed dilutions and choosing the one dilution resulting in 40-70 percent oxygen depletion. The seed dilution giving 40-70 percent depletion is then designated as B_1^* and B_5^* for oxygen levels initially and after 5 days.

$$\text{mg BOD}_5/\ell = \frac{\overset{\text{sample}}{(D_1 - D_5)} - \overset{\text{seed blank}}{(B_1^* - B_5^*)}\ f}{P}$$

where f = $\dfrac{\text{percent seed in sample (should be 0.2 percent)}}{\text{percent seed with 40-70 percent oxygen depletion in series}}$

Table 24.1 BOD measurable with various dilutions of samples*

Using per cent mixtures		By direct pipetting into 300 mℓ bottles	
% mixture	Range of BOD	mℓ	Range of BOD
0.01	20,000-70,000	0.02	30,000-105,000
0.02	10,000-35,000	0.05	12,000- 42,000
0.05	4,000-14,000	0.10	6,000- 21,000
0.1	2,000- 7,000	0.20	3,000- 10,500
0.2	1,000- 3,500	0.50	1,200- 4,200
0.5	400- 1,400	1.0	600- 2,100
1.0	200- 700	2.0	300- 1,050
2.0	100- 350	5.0	120- 420
5.0	40- 140	10.0	60- 210
10.0	20- 70	20.0	30- 105
20.0	10- 35	50.0	12- 42
50.0	4- 14	100	6- 21
100	0- 7	300	0- 7

*From Sawyer, C.N. and P.L. McCarty. 1967. Chemistry for Sanitary Engineers. McGraw-Hall Inc. p 403.

SOLIDS DETERMINATIONS

A. Suspended Solids (SS)
B. Volatile Suspended Solids (VSS)

A. GENERAL

1. Reference: *Standard Methods* (1975) pp. 94-95.

2. Outline of Method: A thoroughly mixed sample is filtered through a glass fiber filter; taking the difference between the filter weight and the filter weight plus the suspended material; dividing that difference by the volume of sample used. The result is Suspended Solids in mg/liter. The filter is then ashed, rehydrated, dried and weighed; the difference between the last two weighings is divided by the volume of sample used. The result is Volatile Suspended Solids in mg/ℓ. The filter is rehydrated after ashing to replace water lost from inorganic compounds exposed to 550°C heat.

B. SPECIAL APPARATUS & EQUIPMENT

1. Glass Fiber Filters: Whatman GF/C - 4.25 cm disc size.

2. Semi-Micro Analytical Balance.

3. Drying Oven & Muffle Furnace.

4. Flat-bladed forceps without serrated tips.

5. Filtration Setup: Side arm flask, pump, funnel. A manostat device set to regulate the suction to the filtration unit to prevent the vacuum becoming greater than 7.5 psi.

C. STANDARDIZATION - NONE REQUIRED

D. PROCEDURE - FILTER PREPARATION

1. Wash filters: Place filter on filtration set up and filter approximately 100 mℓ distilled water (DW). Dry in oven at 103°-105°C then place in muffle furnace at 550°C for 30 min. Remove, cool to room temperature (in a dessicator) and weigh.

PROCEDURE - SUSPENDED SOLIDS DETERMINATION

1. Use smooth forceps at all times to handle filters.

2. Filter as much as will easily pass through the filter. Rinse down the funnel with a small amount of DW. Never add so much sample that the filter becomes clogged and some sample has to be discarded from the funnel.

3. Record the Filter Number, Filter Weight in milligrams (mg), and Sample Volume in liters (ℓ).

4. Place filters in oven and dry for at least 1 hour at 103° - 105°C (usually dried overnight).

5. Weigh the dried filter, which has been cooled to room temperature in a dessicator, and proceed to VSS determination if appropriate.

6. Formula:

$$\text{Suspended Solids} = \frac{\text{(Final Weight - Initial Weight)}}{\text{Sampled Volume Filtered}}, \text{ mg/}\ell.$$

IMPORTANT NOTE: DO NOT EXCEED SUCTION LIMIT OF 7.5 psi.

PROCEDURE - VOLATILE SUSPENDED SOLIDS DETERMINATION

1. Place the filter after the second weighing for SS in a crucible and ash for 1 hour at 550°C in the muffle furnace.

2. Allow the crucible to cool to room temperature; rehydrate the filter with a few drops of DW.

3. Place filter (still in crucible) in oven at 103° - 105°C for a minimum of 1 hour (usually overnight).

4. Cool to room temperature in a dessicator; weigh the filter.

$$\text{VSS} = \frac{\text{(Filter Weight with SS - Rehydrated Ashed Filter Weight)}}{\text{Sample Volume Filtered}}, \text{ mg/liter}$$

SETTLEABLE MATTER

(By Weight)

A. GENERAL

1. Reference: *Standard Methods* (1975) pp. 95–96.

2. Outline of Method: This is a measure of the "settling qualities" of suspended solids and measures the portion of material which settles within one hour. It also includes the material which floats to the surface.

B. SPECIAL APPARATUS AND EQUIPMENT:

1. Glass Vessel: 2ℓ Pyrex beaker.

2. see Suspended Solids, Volatile Suspended Solids.

C. STANDARDIZATION: NONE

D. PROCEDURE (By Weight)

1. Measure suspended solids (see SS method) in total sample.

2. Place the well mixed sample in a glass vessel having $\geq$ 9 cm diameter, $\geq$ 20 cm height, and volume $\geq$ 1300 mℓ.

3. After one hour siphon $\sim$ 250 mℓ of sample from a point halfway between the floatable materials and the settled materials. Do not disturb the surface or bottom material when sampling.

4. Measure suspended solids on this material (the nonsettling matter).

E. CALCULATION

mg/ℓ settleable matter = mg/ℓ suspended solids − mg/ℓ nonsettling matter.