Certification Examination

Study Guide

Collection System Maintenance

Grade IV

CALIFORNIA WATER ENVIRONMENT ASSOCIATION

Collection System Maintenance Grade IV
Study Guide

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Important Notice: CWEA is pleased that you have purchased this book. We want to remind you that this book is one of many resources available to assist you and encourage you to identify and utilize the other resources in preparing for your next test.

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Section 1

Introduction

The California Water Environment Association (CWEA) Technical Certification Program (TCP) is voluntary; its purpose is to educate, prepare, and test an individual's knowledge within six vocations.

- ❑ Plant Maintenance (with two parallel specialties of Electrical/ Instrumentation, and Mechanical Technologist)
- ❑ Laboratory Analyst
- ❑ Collection System Maintenance
- ❑ Environmental Compliance Inspector
- ❑ Industrial Waste Treatment Plant Operator
- ❑ Biosolids Land Application Management

CWEA also assists in educating and training wastewater treatment plant operators for the State of California Operator Certification Tests. Upon qualifying and successfully completing a test, an individual is certified in that specialty at one of the grade levels. Levels within a specialty designate technical knowledge for the apprentice, journey, and management levels. Tests are designed to demonstrate minimum competence for a particular grade.

The purpose of this study guide is to provide a description of the knowledge, skills, and abilities (KSA) needed to pass the test. Also included are questions designed to assess a candidate's strengths and weaknesses relative to their present KSA. Finally, the study guide provides references used to refresh subject knowledge, or to learn more about particular subject areas not completely understood.

Typically there are two to five primary references for each specialty area which need to be read and understood. Test questions are generally based on information contained in these references. Secondary references give more information and often provide a different approach to a subject making it easier to understand.

This study guide is not a compendium of all that may be on the test, so successfully answering questions contained in this guide does not guarantee passing. To successfully pass the Grade I Collection System Maintenance test, the reference materials presented in this study guide should be thoroughly understood.

This study guide can best be used to help identify strengths and weaknesses and to identify material that may need further study. Comments and suggestions to improve the study guide are always welcome and appreciated. Good luck on the test!

Section 2

Certification Program and Policies

CWEA's mission is to enhance the education and effectiveness of California wastewater professionals through training, certification, dissemination of technical information, and promotion of sound policies to benefit society through protection and enhancement of the water environment.

CWEA is a California Nonprofit Corporation, a Member Association of the Water Environment Federation (WEF), and a member of the National Organization for Competency Assurance (NOCA).

Technical Certification Program History

TCP was created to offer multilevel technical certification for individuals employed in the water quality field. Tests are written by vocational specialists and administered twice yearly in six different disciplines: Collection System Maintenance, Environmental Compliance Inspection, Laboratory Analysis, Plant Maintenance (Electrical/Instrumentation and Mechanical Technologist), Industrial Waste Treatment Plant Operation, and Biosolids Land Application Management.

CWEA first offered a certification program for wastewater treatment plant operators in 1937. The program was administered by CWEA until 1973 when the State of California assumed responsibility. During those 36 years, CWEA awarded 3,915 operator certificates.

The first committees were formed in 1975 to establish a voluntary certification program for water quality professionals specializing in disciplines other than plant operation. The Voluntary Certification Program (VCP) emerged with specialized certificate programs for Collection System Maintenance, Plant Maintenance, Environmental Compliance Inspection, and Laboratory Analysis with certifications first issued in April 1976. In the 1980s, two more disciplines were added: Electrical/Instrumentation and Industrial Waste Treatment Plant Operator.

Today, CWEA offers certification in six vocational programs with a total of 22 individual certifications. About 2,000 applications are processed annually and currently over 5,500 certificates are held by individuals in California and neighboring states.

Certification Process

To become certified, *all applicants* must complete the Application for Technical Certification, pay the application fee, have suitable experience and education, and pass the computer-based test. Application instructions and fee schedules are listed on the application. After applications are received at the CWEA office, applicant information is compiled in a database, and reviewed by CWEA staff and subject matter experts for the respective vocation applied for. If approved, the applicant will receive an eligibility letter. If the application is rejected, the applicant will be notified and asked if warranted to supply more information.

After completion of the computer-based test and grading, applicants are mailed official test results. Those who pass the exam, are mailed certificates and wallet cards.

Test Administration

Test Dates and Sites

Tests are given throughout the year in California, Michigan, and Alaska (see Application for Technical Certification for test schedule. Applicants who are eligible to take the test will be mailed an acceptance letter with instructions on how to schedule their exam.

Test Site Admission

Certificate candidates are required to show at least one valid government issued photo identification (State driver's license or identification, or passport). Only after positive identification has been made by the testing proctor may a candidate begin the exam. Candidates do not require to show their eligibility letters to enter the test site.

Test Security

All tests are computer-based. No reference material, laptop computers, or cameras are allowed in the test site. Candidates will have access to an on-screen calculator, however, candidates are welcome to bring their own pre-approved calculator (visit www.cwea.org/cert). Candidates are not allowed to take any notes from the test site. Candidates who violate test site rules may be asked to leave the site and may be disqualified from that test. All violations of test security will be investigated by CWEA and appropriate action will be taken.

Test Rescheduling and Cancellation

To reschedule your application you must submit a written request (a letter stating that you wish to postpone), to postpone to the adjacent testing window. You may only reschedule your application once without a fee. Additional postponent will require a $40 reschedule fee. There are no exceptions to this policy.

To cancel your application you must submit a written request (a letter stating you wish to cancel your application) to CWEA. The written request must be received at the CWEA office no later than 2 weeks after the approved testing window. Full refunds, less the administrative fee of $40.00, will be made within 4 weeks after the scheduled test date. There are no exceptions to this policy.

If you have a scheduled exam with our testing administrator, Pearson Vue, you must contact them 24 hours in advance to avoid losing your exam fee.

Test Result Notification

Test results are routinely mailed to certificate candidates approximately two weeks after the test date. Results are never given over the phone. All results are confidential and are only released to the certificate candidate.

Issue of Certificate/Wallet Card

Certificates and wallet cards are issued to all candidates who pass the test. Certificates are mailed about two to three weeks after result notifications are mailed.

Certificate Renewal

All certificates are renewed annually. The first renewal is due one year from the last day of the month in which the certification test was held. Certificate renewals less than one year past due are subject to the renewal fee plus a penalty fee of 100 percent of the renewal fee. Certificate holders more than one year past due will need to retest to regain certification. Renewal notices are mailed to certificate holder's two months before the due date. It is the responsibility of certificate holders to ensure the certificate(s) remains valid. Continuing education will be required for renewal after 2001.

Accommodations for Physical or Learning Disabilities

In compliance with the Americans with Disabilities Act, special accommodations will be provided for those individuals who provide CWEA with a physician's certificate, or its equivalent, documenting a physical or psychological disability that may affect an individual's ability to successfully complete the certification test. Written requests for special accommodations must be made with the test application along with all supporting documents of disability.

Test Design and Format

Test Design

All certification tests are designed to test knowledge and abilities required to perform the Essential Duties listed at the end of the section

with minimal acceptable competence.

The Essential Duties and Test Content Areas for each certification were determined by a job analysis and meta-analysis of job specifications by two independent psychometric consulting firms. The studies gathered data from on-site visits of over 31 water and wastewater agencies, interviews with 110 water and wastewater professionals, and analysis of more than 300 job specifications. All research was conducted under the guidance of the TCP Committee, vocational sub-committees, and CWEA staff. All test questions are designed to measure at least one area of knowledge or ability that is required to perform an essential duty.

Test Delivery Mechanism

All tests are computer based format and are written in the English language only.

Test Format

All TCP tests are in multiple choice format (see the sample test questions in this booklet for an example). The multiple choice format is considered the most effective for use in standardized tests. This objective format allows a greater content coverage for a given amount of testing time and improves competency measurement reliability. Multiple choice questions range in complexity from simple recall of knowledge to the synthesis and evaluation of the subject matter.

Test Pass Point

The basic minimum score required to pass all tests is 75 percent of possible total points. However, the score may be adjusted downward depending on test complexity. It should be assumed that the passing score is 75 percent and candidates should try to score as high as possible on their test (in other words, always try for 100 percent). The pass point for each vocation and grade level is set independently. Also, each version, or form of a test will have its own pass point. Different versions are given each time the certification test is administered.

How Pass Points are Set

A modified *Angoff Method* is used to determine the pass point for each version of each test. The modified *Angoff Method* uses expert judgements to determine the test difficulty. The easier the test, the higher the pass point; similarly the more difficult the test, the lower the pass point.

The following is an outline of the modified *Angoff Method* (some details have been omitted):

1. A group of Subject Matter Experts (SMEs) independently rate each test question within a given test. The ratings are defined as the probability that an acceptably (minimally) competent person with the requisite education and experience will answer the question correctly. An acceptably (minimally) competent person is defined as someone who safely and adequately performs all job functions and requires no further training to do so.
2. The SMEs review each test question as a group. A consensus is reached for the rating of each test question. The SMEs also review comments submitted in writing by test-takers. Any test question that is judged to be ambiguous, has more than one correct answer, or has no correct answers is eliminated from the scoring process for that test. These test questions are then revised for future use, re-classified, or deleted from the test item bank.
3. After the data are refined, the final step is to calculate the mean, or average, of all the test question ratings. This becomes the overall pass point estimation.

Why Use Modified Angoff?

Each version of a given certification test uses questions from a test item bank. Each of these questions vary in difficulty. Because a different mix of questions is used in each test, the overall difficulty level is not fixed. Thus, it is important to make sure that the varying difficulty level is reflected in the pass point of each test to ensure that test results are reliable. Test reliability is concerned with the reproducibility of results for each version of a given test. In

other words, for a test to be reliable it must yield the same result (pass or fail) for the same individual under very similar circumstances. For example, imagine taking a certain grade level test and passing it. Immediately after completing this test, a different version of the same grade level test is taken. If the test is reliable, the same result will be achieved: pass. If a passing grade is not achieved, it is likely that the test is not a reliable measure of acceptable (minimal) competency.

By taking into consideration the difficulty of the test, the modified *Angoff Method* significantly increases the reliability of the test. Also, since each test is adjusted for difficulty level, each test version has the same standard for passing. Thus, test-takers are treated equitably and fairly, even if a different version of the test is taken.

There are other methods for setting pass points. However, for the type of tests administered by CWEA, the modified *Angoff Method* is the best and most widely used.

Test Scoring

All tests are electronically scored by CWEA. Most test items are valued at one point. Some test items requiring calculations are worth multiple points varying from two to five (possibly more). After tests are scored, total points are compiled and an overall score is calculated as the sum of all points earned on the test. If the overall score is equal to, or greater than the established pass point, the candidate has passed the test. Total points possible for each test varies, but the average is 100 points plus or minus 25.

Item Appeals

Item Appeals

Candidates who wish to appeal a specific test item must do so during the test by completing an Item Appeal during the exam. Candidate Feedback Review Screen will be evaluated and appropriate adjustments will be made to the test content. Candidates submitting feedbacks will not be contacted in regards to the appeal.

Section 3

Skill Sets

This section reviews the managerial and administrative lead/ supervisoryessential duties of a Grade IV Collection System Maintenance Technologist. It also expands the details regarding the knowledge, skills, and abilities required to perform the essential duties.

To successfully achieve a Grade IV classification, Technologists should have full understanding of the Grade I, II and III classification subject matter as well as that for Grade IV. As Grade IV certification candidates, Technologists are expected to have an extensive understanding of the entire spectrum of knowledge related to the field of wastewater collection. Technologists are expected to have a high level of technical knowledge, especially as it relates to maintenance and operations of a wastewater collection system. A complete understanding of the entire spectrum of management practices and techniques is also necessary. Technologists are also expected to possess and use good judgment and have ability to make sound decisions with the ability to implement and communicate these decisions to others. It is highly desirable that Grade IV candidates have strong written and oral communication skills along with interpersonal and public relations skills. This is the knowledge base on which Technologists use during their day-to-day duties within their chosen field of expertise.

This section details the essential duties as listed in the CWEA Candidate Handbook into five topics: Safety; Tools and Equipment; Maintenance; Repair; Construction, and Inspection. Within these five topics are sub-topics wherein the listed knowledge, skills, and abilities are fully incorporated.

Successful Grade IV candidates seeking Collection System Maintenance certification should review the various skill sets presented in this section and seek to understand how they apply to everyday duties and responsibilities. Table 3-1, presented at the end of this section, cross-references each skill set with a specific chapter, section, and/or page of applicable references to assist candidates better understand the subject matter. Subsequently, a thorough study of the reference materials listed is necessary for the successful completion of a certification test.

Skill Set 1 Safety

1.1 General

A safety program is a vital part of wastewater collection system operations and it is imperative that Grade IV operators understand the importance of this program. It is mandatory that Grade IV candidates have a complete understanding of management responsibilities and the purpose and goals of a safety program. A complete understanding of the federal and state laws governing public/worker safety with the hazard communication and worker right to know laws is essential. Grade IV candidates must have the ability to develop and implement policies and procedures for safety-training programs as they relate to the wastewater collection field.

One of the most important abilities for Grade IV candidates is to recognize and identify hazards and hazardous situations encountered above and below ground in collection system maintenance and operations, and to know how to properly rectify those situations. Technologists need to have a full understanding of safety procedures and prevention techniques.

1.2 Traffic

It is necessary to know and fully understand the elements, and techniques of traffic control. Technologists are required to have an awareness and comprehension of the hazards of working in roadways as they pertain to candidates, co-workers, drivers, and pedestrians. Technologists need to have a complete knowledge of traffic safety equipment and their proper use. Technologists need the ability to plan and implement routine traffic control procedures as well as perform non-routine traffic control procedures. The ability to direct subordinates in traffic control operations is also expected.

1.3 Vehicles and Equipment

Grade IV Technologists are expected to have the ability to develop and implement policies and procedures for vehicles and equipment operation and maintenance. Technologists must have a complete understanding of how to perform appropriate safety checks on vehicles/ equipment, and possess a thorough knowledge and understanding of traffic laws, and defensive driving techniques. For safety purposes, Technologists must understand the proper application and operation for the various vehicles, tools and equipment used in collection system maintenance and operations.

1.4 Confined-Space

It is important for Technologists to understand and define what confined-space is and how to identify different types of confined spaces. Knowledge and understanding of confined-space safety rules, requirements, and regulations, as well as accident/injury prevention techniques, is required. Understanding the confined-space permit process, entry procedures and rescue operations, as well as terminology is also important. It is necessary to be aware of and understand the hazards and effects of working in confined spaces and what the responsibilities are. Technologists are able to recognize confined-space safety equipment and its components, and understand its proper function and operation. Technologists must have the ability to develop and implement policies and procedures for confined-space operations and training.

1.5 Chemical and Biological Hazards

Technologists are required to understand potential chemical and biological hazards found in collection system operations. Technologists are expected to be knowledgeable and have ability to develop and implement policies and procedures for prevention of, and protection from, these hazards. The ability to understand and identify the types and proper use of personal protective equipment is required.

1.6 Hazardous Atmospheres

It is important for Technologists to understand what hydrogen sulfide (H_2S) is and its impacts in wastewater collection systems. In addition, Technologists should understand its causes, as well as hazards and effects to both operators and the collection system. It is also necessary to identify the methods used for control of this substance.

Technologists should also know the purposes of air or atmosphere safety monitoring, including monitoring for specific gases or indicators such as carbon dioxide (CO_2), oxygen (O_2), H_2S, and the lower explosive limit (LEL).

1.7 Material Safety Data Sheets (MSDS)

Technologists must have ability to develop and implement a Material Safety Data Sheet program. To accomplish this Technologists are expected to possess a thorough knowledge and understanding of the Material Safety Data Sheet system and their relationship to safety policies, procedures, and implementation, to themselves and coworkers.

Skill Set 2 Tools and Equipment

2.1 Hand Tools and Equipment

Technologists are expected to have the ability to develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of hand tools and equipment. Technologists must be able to identify the application of the various hand tools used in collection system maintenance and operations. Technologists need to understand the characteristics and operation and maintenance of various tools and equipment as they apply to the collection field. The ability to determine the most appropriate selection of hand tools for different circumstances within collection system maintenance and operations is required. Technologists must possess the ability to understand inherent hazards and exercise caution along with the proper use of hand tools.

2.2 Power Tools and Equipment

Technologists are expected to have ability to develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of power tools and equipment. Technologists ability to identify the application of the various power tools and equipment used in collection system maintenance and operations is required, as well as the ability to properly operate and maintain it. Technologists must be able to determine the most appropriate selection of tools and/or equipment for different working conditions and situations. It is necessary to have a full understanding of the characteristics and proper application of power tools/equipment used in the collection field. Technologists must possess the ability to recognize and understand inherent hazards and exercise caution along with the proper use of power tools.

2.3 Heavy Equipment

Grade IV candidates must be able to identify the various types of heavy equipment used in collection system maintenance and operations. It is necessary to understand the unique function and application of the heavy equipment used. Comprehension of the hazards associated with the operation of heavy equipment is expected. Technologists must exercise proper judgment and caution during the operation of heavy equipment. Technologists are expected to have ability to develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of vehicles.

2.4 Vehicles

Technologists must be able to identify and operate the various vehicles used in collection system maintenance and operations. Technologists must understand characteristics and functions of the vehicles used in the collection field. Technologists are expected to have the ability to develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of vehicles.

2.5 Line Cleaning Tools and Equipment

Grade IV candidates must be able to identify the equipment, components, and tools used in line cleaning operations. Technologists must understand the characteristics and functions of these tools, their components and appurtenant equipment, and perform setup and operation and maintenance. The ability to determine the most appropriate selection of tools and equipment for various situations and conditions is essential. It is necessary for the successful candidate to possess the ability to recognize inherent hazards of line cleaning equipment operations, and understand the precautions required for the safe use of equipment. Technologists have the ability to develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of line cleaning tools and equipment.

2.6 Detection and Measurement Devices

Successful candidates to have the ability to identify and properly operate various types of

detection, measurement and safety devices. The ability to determine the most appropriate selection of devices and equipment for various situations and/or conditions is necessary. An understanding of the basic principles and techniques regarding the devices used in the collection field is essential.

Technologists develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of detection and measurement devices. Technologists have the ability to instruct subordinates in the proper operation and maintenance of detection, measurement and safety devices used in collection systems maintenance and operations.

Grade IV candidates must understand the methods and procedures of recording readings from various detection, measurement and safety devices. Technologists must have the ability to interpret and evaluate readings and implement them into collection system operation and maintenance programs.

Skill Set 3 — Maintenance, Repair, Construction, and Inspection

3.1 Wastewater Collection

Successful Grade IV candidates must have the ability to administer and direct operations, services and activities of a wastewater collection system. Therefore, Technologists must have a complete understanding of the principles and purposes of wastewater collection systems (i.e. its components and appurtenant facilities). The ability to understand the characteristics of wastewater, and wastewater flow is necessary. Technologists must have the ability to prepare and delegate job assignments and associated reports and/or records.

Grade IV candidates must have the ability to identify the sources of sanitary sewer overflows (SSO) understand their effects within a collection system, and be able to rectify SSOs. An understanding of the principles of containment, cleanup, assessment and reporting of a SSO is necessary.

3.2 Cleaning and Maintenance

Technologists must be able to define the purpose and goals of a collection system maintenance program, and understand and implement the policies of such a program. Technologists should be able to develop and implement policies and procedures for collection system cleaning, and maintenance and operations. The preparation and presentation of staff reports to upper management based on maintenance performance indicators is required.

The ability to understand a maintenance program's various components, and complete work orders, records scheduling, evaluation of data, assignment of work, cost factors, and reports related to maintenance programs is required. Knowledge of the characteristics and functions of cleaning equipment is necessary, as is understanding its components, purpose, proper operating procedures, and terminology associated with this equipment.

Technologists must have the ability to identify maintenance problems, understand their effects within a collection system, and be able to rectify most problems. The ability to perform stoppage and obstructions assessment, identification and selection of solutions is required.

It is essential that Technologists possess detailed knowledge of the methods of sewer line cleaning, maintenance, and terminology. Technologists must be able to instruct subordinates in the proper methods of sewer line cleaning and maintenance used in collection systems.

3.3 Pipe Repair and Construction (Service and Main Lines)

It is necessary to understand the characteristics of pipe materials, sources of pipe failure, and underground repair techniques. Knowledge of pipe laying methods and procedures is mandatory, as well as understanding excavation methods, bedding, backfill and compac-

tion procedures, and terminology. Technologists must be able to understand and implement underground repair investigation, identification, assessment and estimation. A thorough knowledge of manhole, line, construction and maintenance repair techniques, and terminology is essential. The ability to evaluate cost assessments between various repair methods is required. Technologists should have the ability to develop contract specifications for construction/maintenance projects. The ability to originate and administer the work of contractors and consultants in construction/maintenance projects is required.

3.4 Trenching and Shoring

Grade IV candidates must possess a thorough knowledge of shoring requirements, installation, removal, and the equipment used. Technologists are able to identify soil types and conditions within the trench and apply the proper shoring materials and methods. It is important to know and understand applicable safety procedures and regulations associated with shoring operations. Additionally, Technologists should be able to identify and prevent hazardous situations in trenching operations. Technologists are expected to have the ability to develop and implement policies and procedures to ensure the safe and efficient trench shoring operations. Technologists are able to instruct subordinates in the proper trench and shoring techniques and methods used in collection systems.

3.5 Inspection and Testing

Grade IV candidates are required to manage and administer inspection services on wastewater collection projects. It is important that Technologists be able to understand the need for inspecting and testing as they relate to the wastewater collection field. Technologists must have an understanding of inspection duties and responsibilities. Knowledge of inspection and testing methods, procedures, and equipment is necessary. Technologists must have the ability to interpret and evaluate inspection results and implement them into collection system operation and maintenance programs as well as to prepare and present staff reports to upper management. The ability to interpret drawings (blueprints), maps, and specifications is essential.

3.6 Closed Circuit Television (CCTV) Inspections

Grade IV candidates must be able to understand the purpose and uses of CCTV in collection system operations. Technologists need an understanding of the CCTV equipment operating procedures, components, terminology and maintenance, and repair procedures. Technologists must have an understanding of record keeping and codes used in CCTV. Technologists must have the ability to interpret and evaluate CCTV inspection results and implement them into collection system operation and maintenance programs, as well as to prepare and present staff reports to upper management. Technologists develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of CCTV.

3.7 Mathematics in Wastewater Collection

Mathematical functions are used on a regular basis in the wastewater collection field. Grade IV candidates must be able to perform Grade I, II and III math functions as well as flow rates, velocity, volumes, conversions, slope, cut sheet calculations, horse power, hydraulics, advanced algebra, geometry, time and materials costs, and statistical analysis.

Skill Set 4 Lift Stations and Pumps

4.1 General

Grade IV candidates need to know the function and purpose a sewer lift station has in a wastewater collection system. Technologists need to be able to identify the different types of lift stations, their components, and their purpose. The ability to diagnose and correct lift station component operational problems is also necessary.

There are certain safety issues and hazards found in lift station operations. Technologists must know what these hazards are and be able to take action to prevent accidents from occurring during lift station operation and maintenance. Technologists develop and implement policies and procedures to ensure the safe and efficient operation and maintenance of sewer lift stations.

4.2 Pumps and Controls

Each lift station is equipped with one or more pumps. There are various types of pumps for different needs and uses. Technologists need to identify the various types of pumps and their application.

As with pumps, lift stations are also equipped with various types of control and instrumentation systems. Technologists should be able to identify various types of controls and understand how they work.

The ability to diagnose and correct lift station pump and control operation problems is required.

4.3 Operations and Maintenance

Grade IV candidates need to understand the elements of lift station maintenance and operations. Technologists are expected to have ability to develop and implement lift station maintenance and operation programs.

Technologists need to have the ability to perform troubleshooting of common lift station failures and understand various instrument readings and record information. Technologists must have the ability to interpret and evaluate recorded data and implement them into lift station operation and maintenance programs.

Skill Set 5 Communications, Customer Service, and Interpersonal Relationships

5.1 General

Successful Grade IV candidates need a complete understanding of supervisory and management practices and techniques. Strong written and oral communication, decision-making, and problem solving skills are required, along with interpersonal and public relations skills. Technologists should be able to read, speak, and write in the English language at or above a high school education level. It is important to maintain effective communications with citizens/customers they encounter, their subordinates, co-workers, and with higher management. Technologists need to have the ability to follow written and verbal management instructions, be able to understand verbal and written instruction, and to accurately convey the information to higher management and subordinates. The ability to recognize or anticipate potential problems and implementing a solution or communicating a solution to subordinates and management is required. An understanding of the financial process as well as computer skills and information management systems (IMS) is required. It is essential that successful Technologists have knowledge of federal and state laws governing public/worker safety and how they relate to wastewater collection systems.

5.2 Planning and Organizing

Planning and organizing is a key element of management functions. Grade IV candidates are required to understand the need, various elements, and terminology surrounding the planning and organizing of a wastewater collection system. Technologists need the ability to develop reliable information to establish goals and utilize short and long term planning to carry out these goals. An understanding of the purpose of an organization chart and job duties is required. Technologists also need to have a full understanding of the terms of authority, responsibility, delegation and accountability as they pertain to management functions.

5.3 Human Resources

Technologists need to have a good understanding of the responsibilities of a supervisor, employment policies and procedures and laws governing employer/employee relations. An understanding of new employee application and selection process is required as well as the new employee orientation training and certification. Knowledge of the performance evaluation and disciplinary/harassment processes is necessary.

5.4 Communications and Record Keeping

Good communication skills are essential for Grade IV candidates. Technologists are required to research, analyze, and evaluate information into oral and written reports. It is essential that Technologists have good oral, written and listening skills. The skill to establish and maintain effective working relationships is essential.

Record keeping is a necessary part of Grade IV duties. It is essential that Technologists understand the purpose of record keeping and different types of electronically and written records used in wastewater collection systems.

5.5 Public Relations

An understanding of public relations principles is necessary. Technologists need to understand how to handle customer and mass media related issues.

5.6 Financial

An understanding of financial principles is necessary. Technologists need to have a good understanding of the budgetary process (development and administration), capital improvement, expenditure forecasting, statistical evaluation, cost analysis, and equipment procurement practices and techniques. The ability to develop and interpret financial reports is highly desirable.

5.7 Operations and Maintenance

It is necessary for Grade IV candidates to have a good understanding of a wastewater collection system operations and maintenance program management. It is required that Technologists understand the responsibilities of a supervisor as they relate to wastewater collection system operations and maintenance programs. Also, Technologists must understand the purpose and benefits of operation and maintenance programs including the various types, elements, and terminology related to the management of wastewater collection system operation and maintenance programs.

Table 3-1 Grade IV Collection System Maintenance

		Primary References[a]					
No.	Skill Set	Operations and Maintenance of Colection Systems Volumes I & II	Wastewater Collection System Maintenance	Safety and Health in Wastewater Systems	Confined Space Entry	Utility Management	Wastewater Collection Management
1	Safety						
1.1	**General**	Chapter 4, 11	Chapter 1	All		**Chapter 12**	**Chapters 1 and 7**
1.2	**Traffic** [b]	Chapter 4	Chapter 1	Pages 19-21, 44, 71, 78, 104-105			
1.3	**Vehicle and Equipment**	Chapter 4 Sections 4-4.3	Chapter 1	Pages 73-78			
1.4	**Confined Space**	Chapter 4 Sections 4.4-4.7	Chapter 1 Pages 9-12	Pages 18, 21, 38, 42, 66, 91-97	All		
1.5	**Chemical and Biological Hazards**	Chapter 4 Section 4.43 Chapter 6 Section 6.5-6.57	Chapter 1 Pages 7, 14-17	Chapter 7 Pages 80-88			
1.6	**Hydrogen Sulfide**	Chapter6 Section 6.6	Chapter 1 Pages 7, 14-17	Chapter 7 Pages 80-88			
1.7	**Material Safety Data Sheet**	Chapter 4 Section 4.11	Chapter 1 Page 7	Pages 31, 34, 35, 67, 80, 89, 90			
2	Tools and Equipment						
2.1	**Hand Tools and equipment**	Chapters 7, 12 Section 12.423, 12.420, 12.421	Chapter 7	Chapter 8 Page 104			
2.2	**Power Tools and Light Equipment**	Chapters 3 and 6 Chapter 7 Section 7.33, 7.43 7.45, 7.62 Supplemental Section 3.700 Chapter 12	Chapter 4 Chapter 8				
2.3	**Heavy Equipment**	Chapter 3,4 Chapter 7 Section 7.43 Supplemental Section 3.700					

[a] **Complete reference information given in Section 6**

[b] **Also be familiar with all of *Manual of Traffic Controls for Construction & Maintenance Work Zones* (Complete reference information given in Section 6)**

Table 3-1 Grade IV Collection System Maintenance

		Primary References[a]			
No.	Skill Set	Operations and Maintenance of Colection Systems Volumes I & II	Wastewater Collection System Maintenance	Safety and Health in Wastewater Systems	Wastewater Wastewater Collection Management
2	Tools and Equipment (continued)				
2.4	**Vehicles**	Chapter 6 Section 6.13 Lessons 2, 3, 4 Chapter 12 Sections 12.420, 12.421	Chapter 5	Chapter 6	
2.5	**Line Cleaning Tools and Equipment**	Chapter 6	Chapter 4, 5, 6		
2.6	**Detection and Measurement Devices**	Chapter 3 Section 3.23 Chapter 4 Section 4.52	Chapter 14 page 263	Chapter 8 Page 98	
3	Maintenance, Repair, Construction, and Inspection				
3.1	**Wastewater Collection Fundamentals**	Chapters 1, 2, 3	Chapters 2, 3		Chapter 2 Pages 15-91
3.2	**Cleaning and Maintenance**	Chapters 6, 7, 10 Chapter 3 Supplemental Section 3.7	Chapters 4-6, 8-10 Chapters 13-16		Chapter 2 Pages 79-96
3.3	**Pipe Repair and Construction**	Chapter 3 Supplemental Section 3.7 Chapter 7	Chapters 13-16		Chapter 2 Page 102
3.4	**Trenching and Shoring**	Chapter 7 Section 7.2	Chapter 1 Page 19		
3.5	**Inspection and Testing**	Chapter 7 Section 7.2	Chapter 8		Chapter 3 Pages 64-76
3.6	**Closed Circuit Television Inspections**	Chapter 5 Section 5.41-5.47	Chapter 11		Chapter 3 Page 70
3.7	**Mathematics in Wastewater**	Applications of Arithmetic to Collection Systems			

[a] **Complete reference information given in Section 6**

Table 3-1 Grade IV Collection System Maintenance

		Primary References[a]				
No.	Skill Set	Operations and Maintenance of Colection Systems Volumes I & II	Wastewater Collection System Maintenance	Safety and Health in Wastewater Systems	Utility Management	Wastewater Collection System Management
4	Lift Stations and Pumps					
4.1	**General**	Chapters 3, 8	Pages 27-28			Chapter 4
4.2	**Pumps and Controls**	Chapters 7, 8, 9				
4.3	**Operations and Maintenance**	Chapter 8 Supplement to Cahpters 8 and 9				Chapter 4
5	Communications, and Customer Service, Interpersonal Relationships, and Management					
5.1	**General**	Chapters 10-13		All	All	Chapter 3 Page 83
5.2	**Planning and Organizing**	Chapters 12, 13 Pages 321-322, 408-452			Chapters 3-4	Chapter 3
5.3	**Human Resources**	Chapter 12 Pages 325-337			Chapter 5	
5.4	**Communications and Record Keeping**	Chapters 12, 13 Pages 352-390	Chapter 12		Chapters 6, 7, 13	Chapter 3 Pages 97-100
5.5	**Public Relations**	Chapter 12 Pages 390-393			Chapter 8	Chapter 5
5.6	**Financial**	Chapter 12, 13 Pages 339-340			Chapter 9	Chapters 6, 8
5.7	**Operations and Maintenance**	Chapter 13			Chapter 10	Chapters 2, 3, 4

[a] **Complete reference information given in Section 6**

Section 4

Test Preparation

This section provides tips on how candidates should prepare, information provided with the test, the types of questions likely to be on the test, and solutions to typical math problems.

Basic Study Strategy

To prepare adequately, candidates need to employ discipline and develop good study habits. Ample time to prepare for the test should be allowed. Candidates should establish and maintain a study schedule. One or two nights a week for one or two months should be sufficient in most cases. Spend one or more hours studying in quiet surroundings or in small groups of two or three serious candidates. Efforts should be directed to the test subject areas that are not being performed on a day-to-day basis.

While using this study guide, be sure to understand the answers to all questions. Discuss test questions with others. Not only is this a good study technique, it is also an excellent way to learn.

Candidates should study at the certification level being sought after. There is no advantage to spending time studying material that will not be on the test. Refer to the previous section for topics that will be covered.

It is not necessary, but certainly helpful, to memorize all formulas and conversion factors. A sheet is provided with the test to assist in this area. Tables 4-1 and 4-2 give many of these formulas and conversion factors.

Candidates should obtain the primary reference and training material listed in Section 6. Any material not available at their workplace can be obtained from the sources listed in Section 6.

Multiple Choice Questions

All test questions are written in multiple-choice format. At first glance, the multiple-choice problem may seem easy to solve because so much information is given, but that is where the problem lies. The best answer must be chosen from the information provided. Here are some tips that may help solve multiple-choice questions.

1. Read the question completely and closely to determine what is being asked.

2. Read all the choices before selecting an answer.

3. Look for key words or phrases that often, but not always, tip off correct or incorrect answers:

   Absolute Words
   (Suspect as a wrong choice)

All	**Never**
Always	**None**
Totally	**Completely**

   Limiting Words
   (Often a correct choice)

Few	**Occasionally**
Some	**Generally**
Often	**Usually**
Many	**Possible**

4. Never make a choice based on the frequency of previous answers. If the last ten questions have not had a “b” answer, don’t arbitrarily select “b”. Instead use logic and reasoning to increase the chances of choosing the best answer.

5. Reject answers that are obviously incorrect

Table 4-1 Standard Measurements and Formulas	
12 inches = 1 foot	27 cubic feet = 1 cubic yard
36 inches = 3 feet = 1 yard	1 cubic foot of water = 7.48 gallons
5,280 feet = 1 mile	1 cubic foot of water = 62.4 pounds
1,440 minutes = 1 day = 24 hours	1 gallon of water = 8.34 pounds
144 square inches = 1 square foot	1 million gallons per day (MDG) = 694 gallons per minute
9 square feet = 1 square yard	1 million gallons per day (MGD) = 1.55 cubic feet per second (csf)
43,560 square feet = 1 acre	1 horse power = 0.746 kilowatts (kw)
1,728 cubic inches = 1 cubic foot	Slope = $\frac{\text{Rise}}{\text{Run}}$
Flow	
Q = AV	Q = Flow A = Area V = Velocity
Area	
Rectangle: A = LxW Circle: a = $0.785D^2$	A = Area L = Length W = Width
Volume	
Rectangular Solid: Vol = LWd Right Regular Cylinder: Vol = $0.785D^2L$ *or* Vol = $3.14R^2L$	Vol = Volume L = Length W = Width d = Depth D = Diameter C = Circumference

and choose from the remaining answers. For example, in the multiple choice question, "Why are gasoline and volatile solvents objectionable when present in a sewer?

a. They produce an explosion hazard.
b. They tend to cause solids to vaporize.
c. They will coagulate floatables and cause stoppages.
d. Because they float, the substances flow to plant headworks quicker."

In reviewing physical and chemical characteristics of gasoline and volatile solvents, the specific gravities of these substances are generally less than water and float to the surface. They are solvents for other similar industrial organic chemicals. Therefore, answer "b", that proposes gasoline and volatile solvents cause solids such as sand, and grit to vaporize, is obviously an incorrect answer.

6. Make an educated guess. Never reconsider a choice that has already been eliminated. That means in the example above, answer "b" is out.

   Look for "key" phrases or words that give a clue to the right answer. For the example above, choices "c" and "d" discuss floatables and are potentially good answers. For answer "c", chemical interaction of gasoline with floatables is not likely unless they are oil and grease. In such case, the solvent may disperse the oil and grease and reduce stoppages.

   Answer "a" and "d" remain and are both reasonable choices. However, the best answer must be selected. Answer "d" is true, but without knowing the explosive nature of gasoline and volatile solvents, the answer is only a fact. An explosive material in wastewater creates a condition that endangers the public, a potential loss of expensive facilities, and a hazard to operations and maintenance personnel. The best answer is "a", they produce an explosion hazard.

7. Skip over questions that are troublesome. Mark these questions for later review.

8. When finished with the test, return to the questions skipped. Now think! Make inferences. With a little thought and the information given, the correct answer can be reasoned out.
9. Under no circumstances leave any question unanswered. There is no penalty for an incorrect answer. However, credit is given only for correct answers.

   NO ANSWER=WRONG ANSWER

10. Keep a steady pace. Check the time periodically.

11. Remember to read all questions carefully. They are not intended to be "trick questions"; however, the intent is to test a candidates' knowledge of and ability to understand the written languages of this profession.

Math Problems

Math problems on the certification tests are meant to reflect the type of work encountered in Collection System Maintenance. Although there is no specific math section on the test, many questions will require some calculations such as area, volume, ratios, and conversion of units. By far, the greatest number of applicants that fail the certification examinations do so by failing to complete the math problems. Completing the math problems will be greatly simplified by using a calculator and the approach suggested in the following paragraphs.

Calculators

A scientific calculator may be used during the test; however, a four-function (add, subtract, multiply and divide) calculator is adequate for completing any of the certification tests. Additional functions (i.e. square root) are not necessary, but may be helpful in some situations. The most important factor in effectively using a calculator is the candidates' familiarity with its use prior to the time of the examination. Confi-

dence in the calculator and a full understanding of how to properly operate it are a must. The best way to gain confidence is to obtain the calculator early and use it frequently.

Completing the worksheets in this section as well as the sample problems at the various grade levels will improve proficiency. Additional use will also help. For example, calculate the gas mileage when filling a vehicle's tank each time. Check the sales tax calculation on each purchase. Balance a checkbook, or check a paycheck. The calculator chosen should have large enough keys so that the wrong keys are not accidentally punched. Be certain there are new batteries in the calculator, or use a solar powered calculator with battery back up.

Approach

The solution to any problem requires understanding of the information given, understanding of what is being requested, and proper application of the information along with the appropriate equations to obtain an answer. Any math problem can be organized as follows:

Given or Known. All information provided in the problem statement that will be used to get the correct answer.

Find. A description of the answer that is being requested.

Sketch. If possible, sketch the situation described in the problem statement showing size and shape (dimensions).

Equation. The equation or equations that will be used to generate the listed answers

Assumption(s). Stated assumptions of key information needed to answer a math problem with missing information. This occurs frequently on higher-grade tests.

Answer. This is where the answer is clearly identified.

Advantages to using this approach to organize math problems are that it helps to organize thoughts, breaks the problem solution into a series of smaller steps, reducing chances of making an error.

Solutions

Solutions to math problems are like driving routes from Los Angeles to San Francisco: there are many different routes that can be taken. Some routes are shorter or less complicated than others. Only certain routes end up in San Francisco.

Solutions to sample problems given in this study guide are the most common solutions. If a solution that is different, but arrives at the correct answer is found, then that solution can be used.

Equivalents/Formulas

A sample of the equivalents and formulas sheet from the examination is included in Table 4-1. Familiarity with each of the equivalents (conversion factors) and each of the formulas is important. Pay special attention to the units of measure that are used in the formulas. A correct answer will not be obtained unless the correct units of measure are used.

Check the units, arithmetic, and answer. So that:

1. The units agree.
2. The answer is the same when the arithmetic is repeated.
3. The answer is reasonable and makes sense.

Dimensional Analysis

When setting up an equation to solve a math problem, the trick is to have clearly in mind what units the answer should be in. Once the units have been determined, work backwards using the facts given and the conversion factors known or given. This is known as dimensional analysis, using conversion factors and units to derive the correct answer.

Remember, multiplying conversion factors can be likened to multiplying fractions. The denominator (the number on the bottom of the fraction) and the numerator (the number on the top

of the fraction) cancel each other out if they are the same, leaving the units being sought after.

Example:

If a company runs a discharge pump rated at 50 gallons per minute all day, every day for a year, what is the discharge for the year in millions of gallons per year (MGY)?

Given: pump rating = $50 \frac{gal}{min}$

Find: discharge = ___?___MGY

Calculations: Convert gal/min to million gal/yr, convert gallons to million gallons, and minutes to years.

What is known about minutes and years? There are 60 minutes in an hour, 24 hours in a day, and 365 days in a year. Put that into an equation, and multiply each conversion factor so the unneeded units are cancelled out:

$$50 \frac{\cancel{gal}}{\cancel{min}} \times 60 \frac{\cancel{min}}{\cancel{hr}} \times 24 \frac{\cancel{hr}}{\cancel{day}} \times 365 \frac{\cancel{days}}{yr} \times 1 \frac{MG}{1{,}000{,}000 \cancel{gal}} = 26.28 \text{ mgy}$$

Sample Questions

The following sample math problems are intended to demonstrate unit conversion techniques. Although they are general wastewater problems, the questions may not be specific to any vocation.

1. How many gallons of water will it take to fill a 3 cubic foot container?

$$3 \cancel{\text{cubic feet}} \times 7.48 \frac{\text{gallons}}{\cancel{\text{cubic feet}}} = 22.4 \text{ gallons}$$

2. If a gallon of gasoline weighs 7.0 pounds, what would be the weight of a 350 gallon tank full of gasoline?

$$350 \cancel{\text{gallons}} \times 7.0 \frac{\text{pounds}}{\cancel{\text{gallon}}} = 2{,}450 \text{ pounds}$$

3. The rated capacity of a pump is 500 gal lons per minute (GPM). Convert this capacity to million gallons per day (MGD).

$$500 \cancel{\text{gpm}} \times 1 \frac{\text{MGD}}{694 \cancel{\text{gpm}}} = 0.72 \text{ MGD}$$

4. A chemical feed pump is calibrated to deliver 50 gallons per day (GPD). What is the calibrated chemical feed in gallons per minute (GPM)?

$$\frac{50 \text{ gal}}{\cancel{\text{day}}} \times \frac{1 \cancel{\text{day}}}{24 \cancel{\text{hr}}} \times \frac{1 \cancel{\text{hr}}}{60 \text{ min}} = 0.035 \text{ GPM}$$

5. A chemical feed pump delivers 50 mL per minute (mL/min). Determine the chemical feed in gallons per day (gpd).

$$\frac{50 \cancel{\text{mL}}}{\cancel{\text{min}}} \times \frac{1 \cancel{\text{L}}}{1000 \cancel{\text{mL}}} \times \frac{1 \text{ gallon}}{3.785 \cancel{\text{L}}} \times \frac{60 \cancel{\text{min}}}{\cancel{\text{hr}}} \times \frac{24 \cancel{\text{hr}}}{\text{day}} = 19 \frac{\text{gallon}}{\text{day}} = 19 \text{ gpd}$$

6. A cyanide destruction process is designed to treat 30 pounds of cyanide per 24-hour operational day. How many pounds of cyanide can be treated during an 8- hour shift?

$$\frac{30 \text{ lbs CN}}{\cancel{\text{day}}} \times \frac{8 \cancel{\text{hr}}}{\text{shift}} \times \frac{1 \cancel{\text{day}}}{24 \cancel{\text{hr}}} = \frac{10 \text{ lbs CN}}{\text{shift}}$$

Math Skills

Successful candidates must be skilled in arithmetic, statistics, and geometry. Candidates must be able to apply these skills to make calculations for work-related tasks such as excavation, stationing, pumping, determining flow

rate, cost estimation, and any other job related math skill that may fall within the Skill Sets listed in Section 3. A thorough review of the types of mathematics required for the test is beyond the scope of this study guide. Consult an appropriate math text (see Section 6, References) if there is unfamiliarity with any of these specific math skills. Appendix A provides general strategies for approaching math problems, math anxiety, and resources for remedial study.

Arithmetic

Candidates should be able to perform arithmetic functions such as addition, subtraction, multiplication, and division of numbers and fractions. Candidates should also be able to convert units, calculate financial sewer charges, pumping rates, and pipeline velocity. Some problems are more complex and involve using two or more of the above types of problems. The following example problems illustrate using arithmetic.

Example

A pump must convey 1,000 gpm against a total head of 20 psi. What horsepower is required?

Formula: $\text{Brake Horsepower} = \frac{Q \times H \times SG}{3{,}960 \times \text{eff}}$

Where: Q = flow in gpm; H = head in feet, SG = specific gravity (assume 10 for wastewater); eff = pump/motor efficiency (assume 1.0 since the problem asks for the horsepower, not brake power).

$$\frac{20 \text{ psi}}{1} \times \frac{2.31 \text{ ft}}{\text{psi}} = 46.2 \text{ ft}$$

Substituting into the formula

$$Hp = \frac{1{,}000 \text{ gpm} \times 46.2 \text{ ft} \times 1.0}{3{,}960 \times 1.0} = 11.67 \text{ Hp}$$

Example

A customer discharges 5,000 gallons per day. What is the sewer fees if the sewer rates are $70.00 for the first 5,000 cubic feet and $10.00 per 1,000 cubic feet thereafter?

Convert usage to cubic feet:

$$\frac{5{,}000 \text{ gal}}{\text{day}} \times 30 \text{ day} \times \frac{\text{cu ft}}{7.48 \text{ gal}} = 20{,}053 \text{ cu ft}$$

Minimum charges: $70.00

Remaining discharge to sewer:

20,053 cu ft - 5,000 cu ft = 15,053 cu ft

Additional Charges:

$$\frac{\$10}{1{,}000 \text{ cu ft}} \times 15{,}053 \text{ cu ft} = \$150.05$$

Total charges = $70 + $150.05 = $220.05

Statistics

Grade IV candidates should understand basic statistical concepts such as average. The following example demonstrates this concept.

Example

Find the average daily lift station flow given the following information:

Day	Time	Flow Meter Reading (gallons)
Mon	0800	1,080,000
Tue	0800	2,800,000
Wed	0800	4,610,000
Thu	0800	6,500,000
Fri	0800	8,400,000
Sat	0800	10,150,000

First, calculate the flows for each day by sub-

tracting the previous reading from the present.

Day	Stop Readings (gallons)	Start Readings (gallons)	Daily Flows (gallons)
Mon	2,800,000	1,080,000	1,720,000
Tue	4,610,000	2,800,000	1,810,000
Wed	6,500,000	4,610,000	1,890,000
Thu	8,400,000	6,500,000	1,900,000
Fri	10,150,000	8,400,000	1,750,000

The average is the sum of the values divided by the number of values.

$$\text{average} = \frac{\text{sum}}{\text{no. of values}}$$

sum = 1,720,000 + 1,810,000 + 1,890,000+
1,900,000 + 1,750,000 = 9,070,000 gals

$$\text{average} = \frac{9{,}070{,}000 \text{ gal}}{5 \text{ days}} = 1{,}814{,}000 \frac{\text{gals}}{\text{day}}$$

Geometry

Candidates should be able to calculate perimeters, area, and volumes of circles, squares, rectangles, triangles, rectangular solids, right cylinders, and cones.

Example

If the flow of 500 gpm is entering a 12 foot diameter, 8 feet tall (operating height) tank, what is the detention time?

First, calculate the tank volume using the formula:

$V = 0.785D^2L$

Where v = volume; D = diameter; and
L = tank operating height

$V = 07.85 \times (12 \text{ ft})^2 \times 8 \text{ ft} = 904.32 \text{ cu ft}$

Convert to gallons:

$$904.32 \text{ cu ft} \times \frac{7.48}{\text{cu ft}} = 6{,}746 \text{ gal}$$

Using the formula:

$$t = \frac{v}{Q}$$

Where t = time; v = volume; and
Q = flow rate

$$t = 6{,}764 \times \frac{\text{min}}{500 \text{ gal}} = 13.5 \text{ minutes}$$

Section 5

Diagnostic Test

This section provides a diagnostic exam for those studying for their Grade IV Collection Certification to help determine their current knowledge level of safety; tools and equipment; maintenance, repair, construction, and inspection; lift stations and pumps; and communications, customer service, interpersonal relationships, and management techniques.

These questions represent the type of knowledge that may be required to successfully pass the CWEA Collection System Maintenance certification test. Test questions are generally based on the information contained in the references (See Section 6 for a list of references) and arranged according to the skill sets presented in Section 3. However, correctly answering the example questions is not a guarantee of passing the test.

Test answers, the applicable skill set, and math problem solutions are presented at the end of the Section. Take the diagnostic test, mark wrong answers, and record the skill sets for questions missed. Using table 3-1, candidates should review the references to improve their knowledge of the subject.

Diagnostic Test

Skill Set 1 **Safety**

1. A supervisor could be responsible for an accident, in part or completely by:

   a. providing an unsafe work environment.
   b. requiring work to be performed.
   c. overlooking a potential hazard.
   d. providing the appropriate training and tools.

2. What are the basic elements of a safety program?

   a. Accident investigation, injury frequency rates, safety policy statement
   b. Injury frequency rates, safety policy statement, safety training
   c. Lost time accident statistics, injury frequency rates, accident investigation
   d. Safety policy statement, safety training, accident investigation

3. Who develops Material Safety Data Sheets?

   a. Management
   b. Manufacturer
   c. Salesman
   d. Safety officer

4. Responsibilities of supervisors and managers for a safety program include:

   a. not providing a written safety policy.
   b. never provide safety training.
   c. identify and correct unsafe work practices.
   d. never investigate accidents.

5. What is the intent of the OSHA regulations?

   a. To provide adequate staffing
   b. To put managers in jail
   c. To provide a safe work environment
   d. To provide a safe home environment

6. Which of the following is an infectious disease?

   a. Asphyxiation
   b. Contusions
   c. Hypothermia
   d. Typhoid

Skill Set 2 Tools and Equipment

1. How closely an instrument measures the actual value of the process variable being measured is called its:

   a. accuracy.
   b. calibration.
   c. precision.
   d. standardization.

2. What is a vibrating roller primarily used for?

   a. Asphalt paving
   b. Pipe laying
   c. Line cleaning
   d. Land scraping

3. High velocity cleaning machines use which of the following to clean sewer mains?

   a. High water pressure
   b. Low water pressure
   c. High steam pressure
   d. Low steam pressure

4. What is needed to keep cleaning equipment in good repair?

   a. Tolerance, temper, tools
   b. Talent, temper, tools
   c. Talent, time, tools
   d. Tolerance, time, tools

5. What is the calibration standard used for gas detection meters used in wastewater collection system operations?

   a. Petro-chemical
   b. Public works above ground
   c. Public safety/HazMat
   d. Public works underground

Skill Set 3 Maintenance, Repair, Construction, and Inspection

1. Sources of excessive clear water in a collection system include:

   a. a problem at the wastewater treatment plant.
   b. a water distribution main construction project.
   c. evaporation.
   d. infiltration from a high water table.

2. Closed circuit television in collection systems are used to evaluate:

   a. effectiveness sewer cleaning and clearing techniques.
   b. effectiveness of budget cuts.
   c. effectiveness of pumping cycles.
   d. effectiveness of safety programs.

3. A pump must pump 1,500 gpm against a total head of 40 feet. What horsepower is required?

   a. 14.5 hp
   b. 15.2 hp
   c. 15.5 hp
   d. 16.3 hp

4. If a 35-hp pump is running at 85%, what is the brake horsepower required?

   a. 39.3 hp
   b. 39.8 hp
   c. 40.2 hp
   d. 41.2 hp

5. What is the power cost of a 75-hp pump if the pump runs 144 hours with a power cost of $0.06125/kWh for one week?

   a. $493.04
   b. $494.50
   c. $523.17
   d. $525.00

6. For one week the following flows were recorded daily: 4.6 mgd, 5.2 mgd, 5.3 mgd, 4.9 mgd, 5.4 mgd, 5.1 mgd, 4.8 mgd. What was the average daily flow for the week?

   a. 5.3 mgd
   b. 4.3 mgd
   c. 4 mgd
   d. 5 mgd

7. The following flows were recorded for the months of June, July, and August: June 125.6 MG; July 142.4 MG; August 160.2 MG. What was the average daily flow for this three month period?

   a. 4.65 MGD
   b. 4.69 MGD
   c. 4.72 MGD
   d. 4.85 MGD

8. If the sewer rate is $5.50 for the first 500 cubic feet and all use over the minimum is billed at the rate of 25 cents per 100 cubic feet, how much would a customer discharging 1,200 cubic feet be billed?

   a. $5.25
   b. $6.25
   c. $6.75
   d. $7.25

9. What should be the most important concern of an operator after a SSO?

   a. Aquatic life
   b. Clean-up procedures
   c. Health-related effects
   d. Odors

10. Your system's billing is based on the water usage rate. If your system bills quarterly at a rate of 50 cents/1,000 gallons for the first 10,000 gallons, $0.41/1,000 for the next 15,000 gallons and $0.25/1,000 for all over 25,000 gallons. If a customer uses 35,000 gallons per quarter, what is the bill?

    a. $11.00
    b. $13.65
    c. $21.75
    d. $27.15

11. You have a centrifugal pump that delivers 400 gpm against a head of 200 feet with a combined pump and motor efficiency of 70%. What is the cost for electrical power for operating the pump 12 hours/day for three months of 31 days each? (The electrical cost is 5 cents per kilowatt hour and 1 horsepower = 0.746 kilowatt.)

    a. $1281
    b. $1842
    c. $1214
    d. $1682

12. If a flow of 750 gpm is entering a wet well that is 50 feet long by 20 feet wide by 12 feet deep, what is the average detention time?

    a. 60 minutes
    b. 80 minutes
    c. 100 minutes
    d. 120 minutes

13. What chemical is frequently used to control hydrogen sulfide?

    a. Sodium hypochlorite.
    b. Potassium iodide with sodium sulfide.
    c. Sodium sulfate.
    d. Trinitrotoluene.

14. In selecting pipe material for maximum service life, which factor is most important?

    a. Ease of installation.
    b. Initial cost.
    c. Life expectancy of pipe.
    d. Local manufacturer.

15. How can infiltration into the existing wastewater collection system be reduced?

    a. Enforcing ordinances that require roof drains to be discharged to sanitary sewer system
    b. Inserting plastic liners into sewer pipes
    c. Replacing no hole manhole covers with multi holed covers
    d. Schedule cleaning operation during peak flow hours

16. When using a power rodding machine, why must the location of the clearing tool be known at all times?

    a. So there is enough rod left over if it breaks.
    b. So the operator knows where to place the debris trap.
    c. So the operator will know where to dig to recover the tool if it becomes stuck.
    d. So the operator will know where to place the leader tool if the rod becomes coiled.

17. What is a sand or debris trap used for?

    a. To catch vermin.
    b. To retard flow in a downstream manhole.
    c. Instead of shoveling debris when hydrogen sulfide gas is a problem in the manhole.
    d. To trap material worked loose during cleaning operations.

18. Collection system operators need to know how engineers design collection systems so they can:

    a. Design large, permanent collection systems.
    b. Perform design calculations for the engineers.
    c. Discuss the design with the engineers.
    d. Determine peaking factors for the engineers.

19. Results obtained from pipe roughness coefficient tests can indicate whether or not:

    a. Contamination is entering a pipe.
    b. The ability of the pipe to transmit if flow is being hindered.
    c. The quality of the wastewater in the pipe is deteriorating.
    d. The size and number of leaks are increasing.

20. What affects the flow capacity of a sewer line?

    a. Backfill material, manhole spacing, pipe size
    b. Burial depth, size, manhole spacing
    c. Pipe material, manhole rim elevation, pipe size
    d. Pipe size, pipe material, grade

21. Which of the following types of information should be recorded during TV inspection of a sewer?

    a. Amount of material removed in cubic feet
    b. Distance from manhole to recorded observations
    c. Volume of water used
    d. Tools used

22. Which of these chemicals should be used for odor control in sewers?

    a. Ferric chloride
    b. Muriatic acid
    c. Potassium chloride
    d. Sodium chloride

23. Yokes, rollers, jacks, swivels, pull in machine, and loader are accessories used in:

    a. catch basin cleaning.
    b. jet rodding.
    c. power-bucket machine cleaning.
    d. power rodding.

24. A sewer-use ordinance should specify the personnel performing:

    a. cleaning of the main lines.
    b. monitoring.
    c. repairing of broken pipes.
    d. sealing of leaky joints.

25. What factor must be considered when obtaining an easement for construction and maintenance of a collection system?

    a. Compaction
    b. Deposition of cut materials
    c. Access for equipment and personnel
    d. Manhole headroom

26. Sewer maps should be kept up-to-date for several reasons. Which of the following is the least appropriate reason?

    a. So a TV inspection program can be planned and scheduled effectively
    b. So that census canvassers can determine data on standards of living
    c. So that new house services can be connected with minimum difficulty
    d. To permit development of better plans and specifications for street improvement projects

27. A flat sewer line grade can case sewer maintenance problems. The most likely cause is:

    a. increase in velocity allowing inorganic and organic solids to settle out.
    b. decrease in velocity allowing organic and inorganic solids to settle out.
    c. decrease in velocity allowing gasses to be released.
    d. decrease in velocity allowing an increase in dissolved oxygen.

28. How many feet will a six inch sewer drop in 315 feet with a slope of 0.7%?

    a. 1.16 feet
    b. 1.27 feet
    c. 1.89 feet
    d. 2.20 feet

29. The reason for digging bell holes when laying pipe is to:

    a. provide even bearing between the joints.
    b. provide non-even bearing between the joints.
    c. provide a place to test sand bedding compaction.
    d. provide a mark to check pipe grade.

30. Construction defects that cause problems in wastewater collection systems include:

    a. proper grade of sewers.
    b. improper taps.
    c. watertight manholes.
    d. sand backfill of pipe trench.

31. SSO is an acronym for:

    a. Sanitary Sewer Outfall
    b. Storm Sewer Outfall
    c. Sanitary Storm Overflow
    d. Sanitary Sewer Overflow

Skill Set 4 Lift Stations and Pumps

1. Condition which can cause cavitation in a pump is:

   a. air leak on suction side.
   b. clear water being pumped.
   c. fully opened suction valve.
   d. operating within design curve.

2. Mechanical ventilation of a lift station is required to:

   a. lower temperatures to reduce proportion of hydrogen sulfide.
   b. reduce chlorine demand.
   c. reduce corrosion.
   d. Increase DO in raw wastewater.

3. “Hz” symbol stands for:

   a. Cycles per second
   b. Hand control
   c. Horizontal phase
   d. Polyphase

4. If a three-phase, 220-volt electric motor has just been reinstaled after it has been rewound, and it starts to run in the wrong direction, what corrective action should you take?

   a. Change the ground wire.
   b. Check the motor starter.
   c. Reverse the connection of any two motor leads.
   d. Send it back to the motor repair shop to be properly rewound.

5. What would be considered an acceptable standby system during power outage at a wastewater lift station?

   a. Wind mill.
   b. Hand pump.
   c. Utility power source.
   d. Generator.

6. A wet well design is too large for the flow, causing odors, what would correct this condition?

   a. Increase wet well pump start point.
   b. Decrease pumping time.
   c. Place “spacer” on bottom of wet well reducing wet well volume.
   d. A larger pumping capacity.

7. Which of the following is a part of an electric motor?

   a. Impeller
   b. Rotor
   c. Sleeve
   d. Volute

8. As the impeller wears on a pump, the pump efficiency will:

   a. decrease.
   b. improve.
   c. increase.
   d. not change.

9. The most widely used type of prime mover in a wastewater lift station is:

   a. diesel engine.
   b. electric motor.
   c. gas engine.
   d. steam engine.

Skill Set 5 Communications, Customer Service, and Interpersonal Relationships

1. What are the basic ways for a utility to finance capital improvements?

   a. General obligation bonds, loan funding programs, revenue bonds
   b. Hook-up fees, loan funding programs, revenue bonds
   c. Loan funding programs, revenue bonds, user service charges
   d. General obligation bonds, loan funding programs, revenue bonds

2. Successful communication requires mutual:

   a. agreement.
   b. confusion.
   c. transmission.
   d. understanding.

3. When a great deal of authority is delegated on many levels, an organization may be described as:

   a. authoritarian.
   b. centralized.
   c. decentralized.
   d. unstructured.

4. Recognition and job security are indications of:

   a. a good organization.
   b. a good supervisor.
   c. external morale factors.
   d. internal morale factors.

5. Generally, as an individual progresses upward in management, reliance on personal technical skill:

   a. changes to the more complex.
   b. decreases.
   c. increases.
   d. remains the same.

6. Special parts that should be carried in the inventory are usually listed in the:

   a. blue print.
   b. history record.
   c. manufacturer's manual.
   d. work order.

7. How can the supervisor be certain that scheduled maintenance is completed?

   a. Ask the workers
   b. Hire someone to inspect completed work
   c. Use a form that compares work assigned with work completed
   d. Wait and see if there are any failures

8. Word has just come down from the upper management that operating funds are being cut. How should this be handled?

   a. Cut the supplies and repairs in order to balance the budget
   b. Fire some of the less productive old employees
   c. Keep it quiet and do what you have to do - the less said the better
   d. Let the other personnel know what the situation is and ask for their help

9. One opening has become available which would be advancement to any one of three qualified employees. How should this situation be handled?

   a. Hire an outsider to fill the position
   b. Pick one and notify all personnel of the change
   c. Split the work between the three and leave the position open
   d. Talk to the three as a group, explain the situation and make your selection, then notify all personnel of the change

10. One of the employees in your crew complains about having to do a hard job. The proper thing to do is:

    a. explain that all employees must do their fair share of the hard work as well as the easier tasks.
    b. ignore the complaint.
    c. promise that the next assignments will be easier ones.
    d. tell the employee to shut up and work or quit and go home.

11. Occasionally some of the people on a work crew will indulge in active horseplay. This should be:

    a. discouraged because some of the workers might not like it.
    b. encouraged because it promotes good fellowship.
    c. permitted as it is a form of relaxation.
    d. stopped immediately because it is likely to cause an accident.

12. The managerial function which involves devising an appropriate system of pay is:

    a. controlling.
    b. organizing.
    c. planning.
    d. staffing.

13. For utility records and/or rate analyses purposes, customers with similar patterns of water use are usually grouped together into what classes?

    a. Commercial, domestic, retail
    b. Domestic, retail, industrial
    c. Industrial, domestic, rental
    d. Commercial, domestic, industrial

14. The span of supervision is the:

    a. average length of time required to be in the organization before making supervisor.
    b. number of levels between the lowest employee and the boss.
    c. number of subordinates for each manager.
    d. number of supervisors in an organization.

15. If an organization's departments are organized by jobs to be done, this is known as departmentation by:

    a. customer.
    b. function.
    c. product.
    d. territory.

16. Decentralized authority describes the process of:

    a. changing an organization from centralized to decentralized again.
    b. delegating authority to one's superiors instead of one's subordinates.
    c. delegating power for decisions to lower levels.
    d. retracting authority, which has been previously delegated, and probably changing functions and duties.

17. What term means that the employee reports to one specific supervisor, and that the delegation of authority comes from one particular supervisor to the employee?

    a. Unity of command
    b. Span of supervision
    c. Organizational chart
    d. Formal organization

18. It is generally accepted by psychologists that human behavior is goal-oriented and:

    a. selfish.
    b. random.
    c. other-centered.
    d. motivated.

19. The term "Control", in management practices is:

    a. backward looking.
    b. concentrating on the present.
    c. forward looking.
    d. not connected to the other managerial functions.

20. When purchased materials are first received, they should be:

    a. inspected, counted, and checked against P. O.s.
    b. just sign for and ship out to field crews.
    c. placed on shelves where they will be used first.
    d. inspected, counted, and checked against MSDS.

21. In the steps of the decision making process, which step utilizes outside influences, such as experience, the most?

    a. Analyzing the problem
    b. Defining the problem
    c. Developing alternatives
    d. Selecting an alternative

22. If you were supervisor of two lead workers, one whose work was exceptionally good and a second whose work was substandard, what should you do?

    a. Demote the substandard foreman and bring up a replacement from the ranks
    b. Discuss the problem with the substandard foreman and offer to help before any other action is taken
    c. Find a replacement and then fire the substandard foreman
    d. Wait to see if the substandard foreman does better.

23. Which of the following items is not to be considered in the budget for a Collection System?

    a. Anticipated costs due to labor and maintenance
    b. Anticipated revenues
    c. Insurance
    d. Costs of street maintenance

24. Collection system maintenance programs include:

    a. emergency maintenance.
    b. operation maintenance.
    c. public maintenance.
    d. media maintenance.

25. Recruiting of new employees falls within which category?

    a. Directing
    b. Organizing
    c. Planning
    d. Staffing

26. In record keeping:

    a. every maintenance record should be included in an annual report.
    b. poor records are better than no records.
    c. records should be destroyed every two years.
    d. records should be kept up to date and maintained as long as they are useful.

27. The managerial function, which includes the guiding, teaching, motivating and supervising of Collection system operators is:

    a. staffing.
    b. planning.
    c. organizing.
    d. directing.

28. “Essence of control” is:

    a. written records.
    b. testing.
    c. evaluation.
    d. action.

29. In the evaluation of an applicant for employment, which of the following may enter into your decision?

    a. Age
    b. Education level
    c. Minority classification
    d. All of the above

30. The best way to record all maintenance work is done through:

    a. closed circuit TV.
    b. Polaroid system.
    c. tape recorder.
    d. work order system.

31. Why are good records important?

    a. Demonstrate pattern of lawful behavior over a period of time
    b. To polish your report-writing skills
    c. Record all uncritical events
    d. Give bookkeepers a job

32. What is the term paper screening meaning?

    a. Additional analysis of qualified applicants
    b. Elimination of applicants not qualified for the job
    c. Filing of unsuccessful applicants’ paperwork for future job openings
    d. Review of research papers submitted by a job applicant

33. Which one of the following questions is an acceptable interview question?

    a. What is your religious leader?
    b. What is the nationality of your parents or spouse?
    c. What is your age?
    d. What is your technical background?

34. What is the best approach to solve a discipline problem?

    a. Accept the employee's solution to the problem
    b. Form a committee of peers to make a recommendation
    c. Ignore the problem and it will go away
    d. State the problem and then ask employee to suggest a solution

35. Why is written communication more demanding than oral communication?

    a. Ideas must be expressed clearly
    b. Important information may be missed
    c. Need to use highly technical terms
    d. No chance to clarify and explain ideas in response to audience

36. What is a vulnerability assessment?

    a. Determination of value of utility
    b. Development of an emergency response plan
    c. Estimation of damages for most probable emergency situations
    d. Review of spare parts inventory

37. What are the normal challenges that a manager faces from within a collection system organization?

    a. Equipment needs, resource allocation, local community demands
    b. Local community demands, monitoring from regulatory agencies
    c. Personnel requirements, equipment needs, resource allocation
    d. Resource allocation, local community demands, monitoring from regulatory agencies

38. What kinds of behavior are considered sexual harassment?

    a. Humiliating, Offensive, Invited, Hostile, Annoying
    b. Annoying, Hostile, Humiliating, Offensive, Invited.
    c. Inoffensive, Annoying, Hostile, Humiliating, Uninvited.
    d. Annoying, Hostile, Humiliating, Offensive and Uninvited.

39. Scientific decision making tends to refer to:

    a. using computer techniques on quantifiable information.
    b. problem solving in particular order.
    c. experimentation.
    d. consulting a scientist.

40. A good public relations program will include:

    a. vague and hard to understand billing.
    b. discourage consumer complaints.
    c. prompt response to consumer complaints.
    d. referring all complaints to lawyers.

41. Getting the facts is the first step in what part of the process?

    a. Development of alternatives
    b. Problem analysis
    c. Problem definition
    d. Selection of alternatives

42. When an employee breaks the rules and requires discipline, who is responsible for administering it?

    a. Fellow employees.
    b. Personnel office
    c. Supervisor
    d. Upper management

43. How can the supervisor be certain that scheduled maintenance is completed?

    a. Ask the workers.
    b. Hire someone to inspect the completed work.
    c. Inspect the work.
    d. Wait and see if there are any failures.

44. A purchase order system effectively used provides what?

    a. An accurate and accessible record of purchases.
    b. Data processing printouts of all purchases.
    c. For compliance with the uniform system of accountants.
    d. None of the above.

45. Which term describes the calculated amount by which the value of a collection system physical property declines annually due to wear and tear?

    a. Depreciation.
    b. Rate base.
    c. Rate of return.
    d. Return on equity.

46. What must a manager have to prepare a budget?

    a. Sufficient revenues
    b. Good records from previous year
    c. Budget surplus
    d. Good public relations

47. An information management system helps utility managers make decisions by:

    a. collecting, analyzing, exchanging, storing, and delivering information.
    b. collecting, analyzing, exchanging, deleting, and delivering information.
    c. dispersing, analyzing, exchanging, deleting, and delivering information
    d. collecting, mixing up, exchanging, deleting, and delivering information

48. What are functions of a manager?

    a. Planning, threading, staffing, directing, and controlling
    b. Planning, organizing, staffing, building, and controlling
    c. Padding, organizing, staffing, directing, and controlling
    d. Planning, organizing, staffing, directing, and controlling

49. The three basic ways for a utility to finance a capital improvement program are:

    a. general private bonds, revenue bonds and loans.
    b. planning, organizing, staffing, directing, and controlling.
    c. general obligation bonds, debit bonds and loans.
    d. general obligation bonds, debit bonds and gifts.

Test Answer Key

The following tables show the correct answers for the test questions included in this study guide. The tables below show what section the answers are for, the correct answer, and the subsection the question refers to. If you marked a wrong answer to any of the diagnostic test questions, refer to the subsection listed and you will be able to find the correct reference material to study to help you correctly answer the question.

No.	Answer	Skill Set
1	d	1.1
2	d	1.1
3	b	1.7
4	c	1.1
5	c	1.1
6	d	1.5

Skill Set 2 Tools and Equipment

No.	Answer	Skill Set
1	a	2.6
2	a	2.3
3	a	2.5
4	d	2.6
5	d	2.6

Skill Set 3 Maintainance, Repair, Construction, and Inspection

No.	Answer	Skill Set
1	d	3.1
2	a	3.6
3	b	3.7
4	d	3.7
5	a	3.7
6	d	3.7
7	a	3.7
8	d	3.7
9	c	3.7
10	b	3.7
11	c	3.7
12	d	3.7
13	a	3.1
14	c	3.3
15	b	3.3
16	c	3.2
17	d	3.2
18	c	3.1
19	b	3.2
20	d	3.1
21	b	3.6
22	a	3.1
23	c	3.2
24	b	3.1
25	c	3.3
26	b	3.1
27	b	3.2
28	d	3.7
29	a	3.3
30	b	3.3
31	d	3.1

Skill Set 4 Lift Stations and Pumps

No.	Answer	Skill Set
1	a	4.2
2	c	4.3
3	a	4.2
4	c	4.3
5	d	4.1
6	c	4.1
7	b	4.2
8	a	4.2
9	b	4.3

Skill Set 5 Communications, Customer Service, and Interpersonal Relationships

No.	Answer	Skill Set
1	d	5.6
2	a	5.4
3	c	5.2
4	a	5.3
5	b	5.3
6	c	5.7
7	c	5.7
8	d	5.3
9	d	5.3
10	a	5.3
11	d	5.3
12	c	5.2
13	d	5.1
14	c	5.3
15	b	5.2
16	c	5.2
17	d	5.2
18	d	5.3
19	b	5.3
20	c	5.7
21	c	5.2
22	b	5.3
23	c	5.6
24	a	5.7
25	d	5.3
26	d	5.4
27	d	5.3
28	c	5.3
29	b	5.3
30	d	5.4
31	a	5.4

32	b	5.3
33	d	5.3
34	d	5.3
35	d	5.4
36	c	5.7
37	c	5.2
38	d	5.3
39	b	5.2
40	c	5.5
41	c	5.4
42	c	5.3
43	c	5.7
44	a	5.4
45	a	5.6
46	b	5.6
47	a	5.7
48	d	5.3
49	a	5.6

Selected Problem Solutions

Skill Set 3 — Maintenance, Repair, Construction, and Inspection

4. If a 35-hp pump is running at 85%, what is the brake horsepower required?

Solution.

$$\text{Brake Horsepower} = \frac{\text{Water Horsepower}}{\text{Efficiency}}$$

$$\text{bhp} = \frac{\text{whp}}{\text{Ef}} = \frac{35\text{ hp}}{0.85} = 41.2\text{ bhp}$$

5. What is the power cost of a 75-hp pump if the pump runs 144 hours with a power cost of $0.06125/kWh for one week?

Solution.

First calculate kilowatts required:

$$75\text{ hp} \times \frac{746\text{ watts}}{\text{hp}} = 55{,}950\text{ watts}$$

Then convert watts to kilowatts

$$55{,}950\text{ watts} \times \frac{\text{kw}}{1000\text{ watts}} = 55.95\text{ kw}$$

The power consumption for the week is

55.95 kw x 144 hours = 8,049.6 kWh

Power cost is:

$$8049.6\text{ kWh} \times \frac{\$0.06125}{\text{kWh}} = \$493.04$$

6. For one week the following flows were recorded daily: 4.6 MGD, 5.2 MGD, 5.3 MGD, 4.9 MGD, 5.4 MGD, 5.1 MGD, 4.8 MGD. What was the average daily flow for the week?

Solution.

The average is the sum of the values divided by the number of valves.

$$\frac{4.6 + 5.2 + 5.3 + 4.9 + 5.4 + 5.1 + 4.8}{7\text{ Day}} = \frac{35.3}{7} = 5\text{ MGD}$$

7. The following flows were recorded for the months of June, July, and August: June 125.6 MG; July 142.4 MG; August 160.2 MG. What was the average daily flow for this three-month period?

Solution.

In this case, the average daily flow is calculated by the sum of the monthly flows (total flow) divided by the number of days in the three months.

$$\frac{125.6 + 142.4 + 160.2}{(30 + 31 + 31)} = \frac{(428.2\text{ MG})}{92\text{ days}} = 4.65\text{ MGD}$$

8. If the sewer rate is $5.50 for the first 500 cubic feet and all consumption over the minimum is billed at the rate of 25 cents per 100 cubic feet, how much would a customer using 1,200 cubic feet be billed?

Solution.

$$\text{Cost} = \text{Base} + \text{Excess Use} \times \text{Rate}$$

$$= \$5.50 + \left(\frac{1{,}200 - 500}{100}\right) \text{ft}^3 \times \$0.25/100\ \text{ft}^3$$

$$= \$7.25$$

10. Your system's billing is based on the water usage rate. If your system bills quarterly at a rate of 50 cents/1,000 gallons for the first 10,000 gallons, $0.41/1,000 for the next 15,000 gallons and $0.25/1,000 for all over 25,000 gallons. If a customer uses 35,000 gallons per quarter, what is the bill?

Solution.

$$10{,}000\ \text{gal} \times \frac{\$0.50}{1{,}000\ \text{gal}} = \$5.00$$

$$15{,}000\ \text{gal} \times \frac{\$0.41}{1{,}000\ \text{gal}} = \$6.15$$

$$10{,}000\ \text{gal} \times \frac{\$0.25}{1{,}000\ \text{gal}} = \$2.50$$

$$\$5.00 + \$6.15 + \$2.50 = \$13.65$$

12. If a flow of 750 gpm is entering a wet well that is 50 feet long by 20 feet wide by 12 feet deep, what is the average detention time?

Solution.

$$t\ \text{min} = \frac{V\ \text{gal}}{Q\ \text{gpm}}$$

$$V\ \text{gal} = (l \times w \times h)\ \text{ft}^3 \times \frac{7.48\ \text{gal}}{\text{ft}^3}$$

$$t\ \text{min} = \frac{50\ \text{ft} \times 20\ \text{ft} \times 12\ \text{ft}}{750\ \text{gpm}} \times \frac{7.48\ \text{gal}}{\text{ft}^3} = 119.68\ \text{min}$$

$$= 120\ \text{min}$$

28. How many feet will a six-inch sewer drop in 315 feet with a slope of 0.7%?

Solution.

$$\text{Elevation ft} = (\text{grade, \%}) \times (\text{Run, ft})$$

$$= 0.7\% \times \frac{1}{100\%} \times 315\ \text{ft}$$

$$= .007 \times 315\ \text{ft}$$

$$= 2.20\ \text{ft}$$

Section 6

References

The following section includes the titles and information of primary and secondary references for the Technologist. Because these references contain the majority of the information needed for the CWEA certification test, it is recommended that these references be obtained for personal use. They may also be obtained at a university library or possibly an employer's library.

Primary References

Confined Space Entry, WEF
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800/666-0206
www.wef.org

Manual of Traffic Controls for Construction & Maintenance Work Zones – 1990
State of California
Department of Transportation
1900 Royal Oaks Drive
Sacramento, CA 95815
download: www.cwea.org/tcp/pdf/tcmanual.pdf

Operations and Maintenance of Wastewater Collection Systems
Volumes I & III
Office of Water Programs
California State University Sacramento
6000 J Street, Sacramento, CA 95819-6025
916/ 278-6142 www.owp.csus.edu

Safety and Health in Wastewater Systems, WEF Manual of Practice SM-1
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601 Wythe Street
Alexandria, VA 22314-1994
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Wastewater Collection System Maintenance,
Michael J. Parcher ISBN: 1566765692
CRC Press
800/272-7737 Fax: 800/374-3401
www.crcpress.com

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Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
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Utility Management
Office of Water Programs
California State University Sacramento
6000 J Street, Sacramento, CA 95819-6025
916/ 278-6142 www.owp.csus.edu

Manage For Success: Effective Utility Leadership Practices
Office of Water Programs
California State University Sacramento (CSUS)
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Sacramento, CA 95819-6025
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Secondary References

Applied Math for Wastewater Plant Operators
Joan Kirkpatrick Price ISBN: 0877620892
CRC Press
800/272-7737 Fax: 800/374-3401
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Effective Supervisory Practices: Better Results Through Teamwork
ISBN: 0-87326-176-3
ICM International
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1314 Bedford Ave., Ste 201
Baltimore, MD 21208
410/486-3500
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Supervision Concepts and Practices of Management
by Raymond L. Hilgert and Edwin C. Leonard
ISBN: 0324316240
Thomson Learning
www.thomsonedu.com

What Every Supervisor Should Know
ISBN: 0-07-0055890
Lester R. Bittel and John W. Newstrom
McGraw-Hill, Inc.
800/262-4729
www.mcgraw-hill.com

Appendix A

You and Wastewater Math

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Example math problems found in Appendix A are representative of general wastewater math and are designed to illustrate a math problem solving strategy, not specific math skills. Examples given in this appendix may not be like the problems given on the test for your discipline. However, the problems are typical of types of problems you may encounter, including, but not limited to, basic algebra (solving one equation for one unknown), story problems, and geometry, (area and volume problems). For specific kinds of math skills and problems you may encounter on the Grade IV Collection System Maintenance certification test, please review Sections 3, 4, and 5 of this study guide.

Section 1: Introduction

Now is the time for you to begin preparation for the math portion of your technical certification exam. This Appendix provides suggestions to take charge of:

- ❑ Your math skills
- ❑ Your attitudes toward math
- ❑ Your test-taking skills

By doing this, you can improve your performance in successfully completing the math questions on the certification exam.

Two Facts to Consider

First, since early childhood, you have used math mostly without giving it a second thought. Knowing your age, counting, comparing sizes and shapes, adding your money, and subtracting to get change are math skills.

You drive the streets judging distances, speeds, and times. You estimate if you can afford a vacation or a car and when you can retire. You compare volumes and areas as you build and do jobs around the work site. You even measure volume in putting toothpaste on your toothbrush. You use statistics as you watch sports and consider things like RBIs in baseball or field goal percentages in basketball. All of these are mathematical skills many people take for granted.

Second, if you think math is hard, please know that math becomes hard for *everyone* at some point. You are not alone. There are math problems that have been unsolved for hundreds of years even though they have been attempted by competent, well-informed mathematicians who may work at them for decades. Those are not the problems you need to work unless you are curious. When you work at your appropriate level, you find a combination of easy ideas and hard ideas.

You may get discouraged comparing your speed and understanding in math with others. Those people who appear to do math easily have, most likely, done those specific problems, or ones like them, many, many times.

You will want to study and progress at your "growing edge"—the skill level where you have a bit of discomfort with new material, but where you are not totally overwhelmed. You can expect challenges that trouble you, but that can be overcome. Instead of saying "I cannot do math," decide now to begin learning enough math to make work and test-taking easier.

Move Beyond the Math You Know

To move beyond your routine skill level in math, consider the following points:

You Have Skills. You already have many math skills and can build on that base. It is best and easiest to build on what you already know.
Basics are Important. Going back over the basics of what you know will build confidence

and help you progress and add new math skills to your ability to solve math problems.

Math Progresses Logically. There are many different areas of math and each builds on itself as well as on the others. If you cannot do a particular problem, it may be because you have missed something basic to that one area along the way. Working your way up slowly and cumulatively in math is the fastest way to gain skills.

Words Count. Each and every word and symbol in math means something. You need to find out those meanings and then practice them. If you do not know what "mgd" or "psi" means, or which units measure "flow", it is harder to do problems involving them. It can seem like a foreign language.

Brains are Unique. Each individual brain is wired differently, causing each person to think and learn differently. The more you know about the way you as a specific individual learn, the more you will permit yourself to do what it takes to learn math. Some people need to do many written repetitions. Some need to walk or move around as they do math. Some need to talk out loud. Others need to draw pictures. Some need to work problems with other people. Some need to use words and some need to use symbols. In order to focus on how to move forward, think about what works for you or where learning has been difficult for you.

If you are an independent learner, you might find a basic math book at your library to work through on your own. You may be able to study with your own children to learn some math together or with your friends and colleagues. You may have an old math book you used a long time ago that could be helpful, and you may come to remember what you learned from it.

Assessment Helps. Assess your skill level honestly. Math placement tests are available at your local college and through private educational agencies to help you determine where your skills are and where you can best get help to make comfortable progress.

You are Not Alone. No one promises that math will always be easy or interesting for you. For most people, working on math is a challenge. Persevering and pushing personal limits allows you to experience the satisfaction of success.

Get help when you get discouraged or experience confusion. Remember this is just a momentary problem in a sequence of ideas that you are confronting. Do not buy into the myth that you have to do math alone. Do not believe it is demeaning for you to admit you do not understand. You can have fun if you lighten up as you progress. Working with others is an outstanding way to improve math skills.

Questions are Essential. Make a list of people with whom you feel comfortable discussing your math questions. They may be your colleagues, teachers, fellow students, friends, or family members—even your children. Do not ask just anybody; pick people who are helpful and positive or non-judgmental about your questions.

Mistakes Happen. Expect mistakes up front. As you learn anything new, you will make errors. Do not blame your mistakes on math itself! In any new endeavor you need to allow yourself to crawl before you can walk. Successful people in all fields know this. Trial and error is the basis of all learning.

You can learn more from your mistakes than from repeated successes. Making errors gives you feedback by showing you what you do not understand. Learn to value and accept those errors and use them to find out what areas of your learning need more work. Correct them and then move on with new knowledge.

Learning Math is Not a Competitive Game. Physicist Albert Einstein, politician Winston Churchill, and inventor Thomas Edison were all considered slow in school. Musical composer Ludwig Van Beethoven and scientist Louis Pasteur probably had learning disabilities. What all five certainly had was determination and patience to persevere. Only compete with yourself, pushing yourself forward, in learning math.

There is Hope for Those with Learning Disabilities. If you really have a hard time learning, you might ask your local college or a private learning specialist to assess you for a learning disability. Many colleges and universities do free testing and training for their students. You can also purchase this kind of assistance from private consultants. Much is now known about learning disabilities and how to help people who have them. Learning disabilities often become just learning differences as students learn to honor and use their own thinking and learning styles.

Math Success and Test-Taking Success are Not the Same. Many math students understand and can work math problems, but have difficulty in test-taking situations. It is possible to know math and still fail exams. These people may find Section 4 "Test-Taking Strategies" very helpful. Conscious practice of both math skills and test-taking skills can make a big difference in your score.

Resources are Available. Resources exist for all types of math. You will need to decide whether you will work on your math skills independently or with the help of some structure such as a math course or a tutor. Different strategies may work better at different stages in your progress.

Your local community college has inexpensive math courses. Some colleges even have math courses specifically for water and wastewater professionals. Professional organizations sponsor training conferences and seminars which include math courses specific to the field. Many agencies can provide in-house training and many agencies will provide individual help with all aspects of test taking.

Community Colleges. Community colleges offer several types of services including:

- ❑ Math Placement Testing
- ❑ Math Courses
- ❑ Water Utility Science Courses
- ❑ Math Anxiety Reduction Courses
- ❑ Testing and Training for those with Learning Disabilities

Professional Organizations. Organizations such as the California Water Environment Association (CWEA), American Water Works Association, and American Public Works Association also provide opportunities to practice your math skills and network with others:

- ❑ Technical Certification Training Classes and Annual Conferences
- ❑ CWEA Northern and Southern Regional Training Conferences
- ❑ CWEA Study Manuals

At Work. Ask for help and suggestions from others who have taken math courses or are skilled in the work area similar to the one you are trying to prepare or improve. Ask your supervisor for advice on how to prepare and how much time on the job you can have to prepare. Ask your supervisor to provide training classes for the areas that you are wanting to improve. Ask those managing other departments, agencies, or local professional organizations for help in the training you need.

Materials. Any basic math book or instructional manual that you can beg, borrow, or buy, including:

- ❑ Courses from Ken Kerri, Office of Waste Programs, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819.
- ❑ Price, Joanne Kirkpatrick. *Basic Math Concepts for Water and Wastewater Plant Operators*. Lancaster, Pennsylvania: Technomic, 1991.
- ❑ Smith, Richard Manning. *Mastering Mathematics: How to Be a Great Math Student*, 3rd Ed. Pacific Grove, CA: Brooks/Cole, 1998.
- ❑ Zaslavsky, Claudia. *Fear of Math*. New Brunswick, NJ: Rutger University Press, 1994.

Section 2: Practice Problem Solving Strategies

Wastewater math deals with only a handful of basic types of problems that involve moving liquids and semi-solids from place to place, and manipulating, storing, and treating these substances along the way.

So basically, understanding area, volume, slope, rates, concentrations, costs, and time elements that occur in wastewater treatment 24 hours per day, 365 days per year, pretty much covers what you need to know.

Units and Arithmetic

All wastewater math problems can be solved by simple arithmetic—adding, subtracting, multiplying, and dividing. You can become proficient with wastewater math by paying careful attention to the units in the problems as you write down your strategies, and then using a calculator to do the needed arithmetic.

Units. Units such as cubic feet, gallons, gpm, and mgd are important in wastewater math problems. Paying attention to the units will tell you whether to multiply or divide. Also, the units will often help you know what numbers to multiply or divide.

Notice in each example that doing math operations on the units produces the correct units in the answer. Many people do the math on the units first to figure out the correct procedure before they ever do the math on the numbers.

Multiplying. Multiplying is important. There are several symbols for multiplication. They are •, x, and ()().

For example,

$2 \bullet 3 = 2x3 = (2)(3) = 6$

Dividing. Dividing is important to wastewater math because units often used such as mgd, cfs, ppm, gpm, psi, mg/L, gpd/sq.ft., and % are really division problems.
"Per" stands for "divided by".

$$\text{mgd} = \frac{\text{million gallons}}{\text{day}}$$

$$\text{cfs} = \frac{\text{cubic feet}}{\text{second}}$$

$$\text{ppm} = \frac{\text{parts}}{\text{million}}$$

$$\text{gpm} = \frac{\text{gallons}}{\text{minute}}$$

$$\text{psi} = \frac{\text{pounds}}{\text{square inch}}$$

$$\text{mg/L} = \frac{\text{milligrams}}{\text{Liter}}$$

$$\text{gpd/square foot} = \frac{\text{gallons/day}}{\text{square foot}}$$

$$10\% = \text{ten percent} = \frac{10}{100}$$

Example Problems

Example 1

Plant No. 1 measured a flow of 3.5 million gallons in half a day. If the peak flow (hydraulic) capacity of the plant is 8 mgd, is there need for concern?

Using the conversion factor:

$$\text{mgd} = \frac{\text{million gallons}}{\text{day}}$$

divide 3.5 million gallons by half a day.

$$\text{mgd} = \frac{3.5 \text{ million gallons}}{0.5 \text{ day}} = 7 \text{ mgd}$$

7 mgd is less than the peak flow capacity, 8 mgd. There is no need for concern yet.

Example 2

a. Find the number of gallons in 10 cubic feet.

Since we can pour 7.48 gallons into a 1 cubic foot container, that means that 7.48 gallons = 1 cubic foot. We can use either factor:

$$\frac{7.48 \text{ gal}}{1 \text{cu ft}} \text{ or } \frac{1 \text{ cu ft}}{7.48 \text{ gal}}$$

to convert cubic feet units into gallons or vice versa

$$\frac{10 \text{ cu ft}}{1} \bullet \frac{7.48 \text{ gal}}{1 \text{cu ft}} = \frac{(10 \text{ cu ft})(7.48 \text{ gal})}{1 \text{ cu ft}}$$

$$= 74.8$$

Notice that using the first factor allows the unit "cu ft" to cancel out leaving the answer in gallons.

b. Find the number of cubic feet in 10 gallons. Notice that using the second factor allows the unit "gal" to cancel out leaving the answer in cubic feet.

$$\frac{10 \text{ gal}}{1} \bullet \frac{1 \text{ cu ft}}{7.48 \text{ gal}} = \frac{(10 \text{ gal})(1 \text{ cu ft})}{7.48 \text{ gal}}$$

$$= 1.34 \text{ cu ft}$$

You will notice how important it was in these examples to consider the units in deciding whether to multiply or divide by 7.48.

Example 3

a. Find the detention time for a basin with 675,460 gal if the flow is 1,000,000 gal/day.

Flow is always a rate which is division. Units like gpd or cfs are both division.

The formula for the basin detention time is

$$D_t = \frac{\text{volume}}{\text{flow}}$$

$$D_t = \frac{675{,}460 \text{ gal}}{1{,}000{,}000 \text{ gal/day}}$$

$$= \frac{675{,}460 \text{ gal}}{1} \bullet \frac{\text{day}}{1{,}000{,}000 \text{ gal}} = 0.675 \text{ days}$$

b. Find the detention time for a 426 cubic foot basin if the flow is 1,000 cfs.

$$D_t = \frac{426 \text{ ft}^3}{1{,}000 \text{ cfs}} = \frac{426 \text{ ft}^3}{1{,}000 \frac{\text{ft}^3}{\text{sec}}} = \frac{426 \text{ ft}^3}{1} \bullet \frac{\text{sec}}{1{,}000 \text{ ft}^3}$$

$$= 0.426 \text{ sec}$$

Example 4

Find the number of gallons of an 11% polymer needed to produce 100 gal of a 0.75% solution. Use the formula $C_1V_1 = C_2V_2$ where C = concentration or % and V = volume.

You can let the volume you are looking for (i.e. the number of gal of 11% polymer) be represented by V_1. Then C_1 = 11% or 0.11, C_2 = 0.75% or 0.0075, and V_2 = 100 gal.

Using the formula $C_1V_1 = C_2V_2$, you have $(0.11)(V_1) = (0.0075)(100)$

Notice to find V_1, you do the opposite of multiplying (i.e. dividing) by 0.11 on both sides. You then have

$$\frac{(0.11)(V_1)}{0.11} = \frac{(0.0075)(100)}{0.11}$$

and using a calculator, V_1 = 6.82. So, the amount needed is 6.82 gal.

Example 5

How many hours will it take to empty a 43,000 cubic foot tank if it empties at a rate of 2.7 cubic feet per second?

Notice that dividing 43,000 cubic feet by 2.7 cubic feet per second would make the cubic feet unit cancel out. This would give us the time in seconds. To convert seconds into hours, use the factors

$\frac{1\ \text{min}}{60\ \text{sec}}$ and $\frac{1\ \text{hr}}{60\ \text{min}}$.

The work is given below.

Notice how the units cancel out leaving the answer in hours.

$$\text{Time} = \frac{43{,}000\ \cancel{\text{ft}^3}}{2.7\ \frac{\cancel{\text{ft}^3}}{\cancel{\text{sec}}}} \cdot \frac{\cancel{1\ \text{min}}}{60\ \cancel{\text{sec}}} \cdot \frac{1\ \text{hr}}{60\ \cancel{\text{min}}} = 4.42\ \text{hr}$$

Example 6

Find the number of gallons of water in a rectangular basin 200 ft long, 50 ft wide, and 12 ft deep.

First, find the volume of the rectangular basin by multiplying length by width by height. Volume = (200 ft)(50 ft)(12 ft) = 120,000 cubic feet or cu ft or ft^3.

You now have a problem similar to Example 2. How many gallons are there in 120,000 cubic feet?

Use the factor $\frac{7.48\ \text{gal}}{1\ \text{cu ft}}$ to convert cubic feet into gallons.

$$\text{volume} = \frac{120{,}000\ \text{cu ft}}{1} \cdot \frac{7.48\ \text{gal}}{1\ \cancel{\text{cu ft}}} = 897{,}600\ \text{gal}$$

Example 7

A cylindrical tank is full to 3 feet below the top at 10 a.m. and empty at 4 p.m. If the tank is 50 ft tall with a diameter of 70 ft, find the volume (in gal) of the liquid at 10 a.m. and the rate of flow from the tank in gal per minute.

For a math problem with many words, I recommend always first writing down what you are trying to find:

a. First, find the number of gal of water in the tank at 10 a.m.

b. Second, find the rate of flow in gal/min.

Drawing a sketch helps some people understand the problem and helps to keep track of the data.

I also like to write down and interpret the details that are given to me like:

Full to 3 ft below the top at 10 a.m.
Empty at 4 p.m.
Takes 6 hours to empty

The solution is presented in two parts.

a. First, to find the volume in gal at 10 a.m., use the formula for volume of a cylindrical tank which is V=(area of the base) times (height).

   To find the area of the base of the tank which is a circle, multiply 0.785 times the diameter squared.
   So, the area of the base = $0.785(70^2)$ = 3,846.5 sq ft.

   The height at 10 a.m. is 47 ft because the tank is filled to 3 ft below the top.

   Volume = (area of the base)(height) = $(3846.5\ ft^2)(47\ ft) = 180{,}785.5\ ft^3$

   However, you want the volume in gal so use the factor $\frac{7.48\ \text{gal}}{1\ \text{cu ft}}$ to convert.

   Volume in gallons =

$$(180{,}785.5\ ft^3)\left(\frac{7.48\ \text{gal}}{1\ ft^3}\right) = 1{,}352{,}275.54\ \text{gal}$$

b. Second, to determine the rate of flow in gallons per minute, divide the number of gallons by the number of minutes it took the tank to empty. It took 6 hours to empty. To convert 6 hours to minutes, use 60 min = 1 hour or factors $\frac{60\ \text{min}}{1\ \text{hour}}$ or $\frac{1\ \text{hour}}{60\ \text{min}}$ to convert. You want the hour unit to cancel out, so you will use the first factor. The time becomes:

$$\left(\frac{6\ \cancel{\text{hrs}}}{1}\right)\left(\frac{60\ \text{min}}{1\ \cancel{\text{hr}}}\right) = 360\ \text{min}$$

Rate of flow in gal per minute =

Rate of flow in gallons per minute =

$$\frac{1{,}352{,}275.54}{360\ \text{min}} = 3{,}756.32\ \text{gal per min}$$

Section 3: Take Charge of Your Success

The key to progress with math is to consciously take charge of your thoughts and actions. Then, instead of letting math control you, you control math and you take charge of your success.

Recommendations

Ask Questions. Be active and assertive. Learning is not a spectator sport. You cannot learn well from the sidelines. Get involved. Work problems and keep asking questions until they become clear. In classes and seminars, ask questions on confusing procedures.

Take It Easy. When you get stuck working problems, hang in for a while and then take a break. Go back later, begin at the beginning with a clean sheet of paper and a different point of view. Just because you do not understand at first does not mean understanding will not come. Math learning requires time to settle into your brain. Being able to live with uncertainty for a while is a good math skill to have.

Keep a List. Write down your resources (books, tutors, people to answer questions, people who understand) so that you can consult them when you get discouraged. You are not alone. Find helpful people with whom you are comfortable. Form a network with others working toward the same goals as you.

Find Yourself. Discover your own unique ways of learning. Experiment with new ones. If a method does not work, find others. Ask different people how they learn math or do a problem. They will often feel honored and pleased that you asked them and you might get a breakthrough idea.

Be Positive. Listen to what you say to yourself inside your head. It is difficult to work well if you are saying, "I will never get this" or "I cannot do math." Change those negative messages to neutral ones like "I have not learned this *yet*" or "I cannot do this particular problem *yet*."

Reward Yourself. Acknowledge your progress—every little bit! Pat yourself on the back for each and every problem you work. Notice what you know now that is new that you did not know two weeks ago. Maybe even write it down to document your growth.

Learn From Mistakes. Remember that errors are part of the learning process. Pay attention to them and figure out where they happened and how to fix them.

Keep It Real. Be realistic with your expectations of yourself—your math level, your life commitments, and your time constraints. Do not beat yourself up for being a human being.

Use Technology. Learn to use a calculator and use it appropriately for calculations with large numbers and decimals. Each brand of calculator is different so keep your manual for reference. Take spare batteries to exams.

Start Easy. Practice the easier math problems to warm up each time you begin your math study. This builds confidence and strengthens those math pathways in your brain.

Use Paper. Keep scratch paper available and expect to use it for your math work. You need empty space on paper to think and do calculations.

Promote Emotional Well Being. Patience, self-care, and humor will make your math work so much easier. Your brain will work better too.

Be Healthy. You are making new connections in your brain as you practice math so sufficient

sleep and healthy foods are important. Having fresh drinking water available and breathing fresh air also helps you think better.

Section 4: Test-Taking Strategies

There are many actions you can take before, during, and after exams that will improve your test-taking performance and outlook. Remember that math skills and test-taking skills are different from each other. This section will help you become conscious of your thoughts and actions regarding test preparation. Use these suggestions to take charge and approach your test confidently.

If you find yourself thinking negative thoughts about your coming exam, skip to the last section and read "Negative Thinking about Exams" first.

Before the Exam

Work Problems. Diligently prepare and practice. Repeat solving problems to gain speed and confidence. This takes work and time—sometimes many hours, even days. Going in to an exam with the knowledge that you have worked lots of problems boosts confidence. Prep time is invaluable.

Relax. Practice relaxation daily for about at least ten minutes using breathing. Sitting or lying comfortably, breathe slowly in through your nose counting to five and then out through your mouth counting to ten. If you feel dizzy, breathe normally for a while. Deep breathing activates chemicals in your body that help you relax and feel better. Any type of regular meditation, yoga, or slow stretching while breathing deeply can help facilitate your relaxation response. Practicing daily will help you control your adrenaline level during your exam. Using relaxation consciously during an exam frees up the thinking part of your brain. (Do not practice these deep breathing exercises while you are driving.)

Stay Active. Daily walks or biking or whatever aerobic exercise you use consistently prepares your body for your exam by relieving stress and keeping your state of mind positive. Your mind and your body are connected so tightly that they are nearly the same.

Rehearse. Do a dress rehearsal for your exam. Write or have someone assist you in writing a practice test with problems and questions that you think might be on the real exam. Use questions from the prep materials listed on page A-5 and A-6. Give yourself this practice test in an environment as close to your testing situation and schedule as possible. Time it and then correct it to learn from your errors.

Plan Ahead. Plan ahead carefully so that you will get to the exam early—do not be in a rush. Know exactly how to get there and what you will wear so that you are comfortable. You might want to wear your "lucky" shirt or bring a photograph in your wallet of people who care about you and believe in you. WHATEVER you can do to increase your sense of comfort and security, do it. Ahead of time, pack a Testing-Taking Kit with sharp pencils, pens, a ruler, erasers, tissues or handkerchief, a bottle of water, extra calculator batteries, and anything else you think you might need that is allowed at the test.

Care For Your Body. Optimal food and rest are individual preferences. Plan these ahead of time. Some research has shown that a brisk walk before an exam has raised test results. Some research has shown that eating a few candies (not chocolate) right before an exam has raised test results. Protein appears to be essential for clear thinking. Be in charge of what happens to you before the exam. Do not let outside influences take charge of you for this little time before your test.

At the Exam

Do a Data Dump. Bring a short list of formulas or facts you find difficult to remember. Look at them before the test. Visualize them going into a holding tank in your brain. Practice making them subject to recall. If you are not allowed to use notes on the exam, be sure to put the list away so that your honesty is not questioned. When you receive your test, quickly write these

formulas or facts on your exam paper. Now you do not have to expend any energy trying to recall them later when you need them.

Ignore Others. Ignore all of the other people at the exam—before, during, and maybe even after. Different people have different ways of dealing with their anxiety during tests. Some people get a little hyper and try to rub off their anxiety on everyone else. Do not take on someone else's anxiety. Your test is not a competition so what other people do will not affect your score. Often the first person to leave an exam gets a very low score, while the last person to leave gets a very high score. Take your time. Pay no attention to other people's behavior.

Breathe. When you feel stuck or tense, take a deep breath. Let it all go as you expel the air. (The more you have practiced relaxation and deep breathing before the exam, the more you will relax during the test.)

Take Time Out. Take short breaks during the exam to close your eyes, breathe deeply, and stretch your neck and arms. Massaging your temples, scalp, and the back of your neck will increase blood flow with oxygen to your brain to help you think better. A few isometric exercises can release tension too.

Use Your Subconscious Mind. If a problem makes no sense, read it and go on. Ideas will come to you as the problem sinks into your subconscious mind while you continue with the test.

Trust. Let each question reach into your mind for the answer. Remind yourself that you know everything you need to know for now.

Strategize. Do the easy problems and questions first. Make pencil marks by the questions to which you want to return.

Use Time Wisely. Do not work on one problem for a long time. Often a question further into the exam will act as a "key" to unlock a previous problem. Tell yourself that you have all of the time you need. Let go of the rest of your life during the exam. You can deal with all that later.

After the Exam, Let the Results Go. You have used a lot of energy and may be low and off balance. You may wish to pass up discussing the exam with others so you can take care of yourself. Going to the bathroom, drinking some water, and eating something can help you feel normal again. You may have set much of your life aside to prepare for this exam. Refresh yourself and get your life back. You can deal with the test results later when your priorities are in order again.

Negative Thinking About Exams

Here are negative thoughts math students often think before test-taking. Put a check mark by the examples familiar to you. Recognizing the distorted thinking in each example can help you change negative thoughts to neutral or positive ones. If you need more assistance with overwhelming negative thoughts, I recommend the book *Feeling Good* by David Burns (WholeCare, 1999).

"I Will Fail." Unless you have a crystal ball and can see into the future OR unless you have made a definite plan NOT to prepare for the test OR unless you plan to "freeze up" during the exam, you have no way of knowing whether you will fail or not. Worrying about the future only takes energy from today.

"I Will Panic During the Test." It is not uncommon to be excited. An exam is a process during which you will experience many thoughts, feelings, and body sensations. Actors get nervous, yet they still perform. If you do panic, let panic leave you. It will. No one dies from panicking during an exam.

Preparation by practicing problems, asking questions, and reviewing gives you confidence and skills that you need. Taking a dress rehearsal test and trying to panic can help you practice dealing with out-of-control feelings. Learning some relaxation techniques to use before and during the exam calms you and aids clear thinking. The more you prepare yourself

ahead, the more you are in charge and feel relaxed.

"I Cannot Do Math." Math is a very broad subject involving many different skills. If you can recognize shapes, tell time, and know where the front and back of a classroom are, you can already do math. There are many more math skills that you have and many that you do not have YET. There are also many that you will never choose to acquire. Instead of thinking so absolutely about math, find areas where you can grow and learn new skills instead of paralyzing yourself with this broad generalization.

"I Am Stupid." Name calling is seldom productive. Occasionally you may feel stupid because you do not know something or you mess up. What really is happening is that you are being human and humans are not stupid. Educators recognize the need to change how everyone thinks about intelligence. They recognize that there are many different kinds of intelligence including:

- ❑ bodily/kinesthetic
- ❑ verbal/linguistic
- ❑ naturalist
- ❑ logical/mathematical
- ❑ visual/spatial
- ❑ interpersonal
- ❑ intrapersonal
- ❑ musical/rhythmic

This comes from the work of Howard Gardner [Gardner, Howard. *Multiple Intelligences: The Theory in Practice*. New York: Basic Books, 1993].

You are a wonderful combination of these talents—not just an IQ number. IQ Tests are limited because they only measure a few types of intelligence and ignore the rest. We are not all the same and cannot possibly know all there is to know in every situation. Between now and the exam, there are many questions you can get answered as well as many new skills you can practice and master if you use the skills and intelligence that you have.

"I Will Forget Everything." Forgetting does not mean something is gone from your mind forever. The right cue will often help you remember what you need to know. Your exam will be filled with cues—words and symbols—that will trigger formulas and ideas you have practiced.

Expecting to forget "everything" is foretelling the future and making a broad generalization. Even most people with amnesia caused by illness or injury do not forget "everything." If you are extremely worried about your memory, *The Great Memory Book* by Karen Markowitz and Eric Jensen (The Brain Store, 1999) can be of assistance to you.

"Math Tests Are Tricky." Math students who rely on memorizing the material rather than understanding it are usually the ones who think tests are tricky. You will use your memory to add to your understanding of how to do the math. Your math problems will contain many units such as mgd or ft^3 or psi. Learning how to skillfully convert back and forth between units of measure will take a lot of the trickiness away from your test problems. Practicing using your calculator will help too.

"There Is So Much I Do Not Know." This will always be the case the rest of your life. It is the human condition. Taking a deep breath and finding the level where you can begin to learn will improve your feelings and your confidence.

Appendix B

Glossary

Technical Terms

Air gap: An open vertical drop, or vertical empty space, between drinking (potable) water supply and the non-potable point of use. This gap prevents back siphonage because there is no way wastewater can reach the drinking water. Air gap devices are used to provide adequate space above the top of a manhole and the end of the hose from the fire hydrant. This gap insures that no wastewater will flow out the top of a manhole, reach the end of the hose from a fire hydrant, and be sucked back up the hose to the water supply.

Asphyxiation: An extreme condition often resulting in death due to lack of oxygen and/ or excess of carbon dioxide in the blood from any cause.

Atmospheric: Of or relating to the atmosphere.

Backfill: 1) Materials used to fill in a trench or excavation. 2) The act of filling a trench or excavation usually after a pipe or some type of structure has been placed in the trench or excavation.

Backflow: 1) A device that is placed in a sewer lateral to prevent accidental backflow or reverse flow of wastewater into a building. 2) A device used on potable water systems to prevent water from flowing back into a main from a private service line thereby eliminating any possible contamination.

Balling: A method of hydraulically cleaning a sewer or storm drain by using the pressure of a water head to create a high cleansing velocity of water around the ball. Special sewer cleaning balls have an outside tread causing them to spin or rotate resulting in a scrubbing action of the flowing water along the pipe wall.

Bedding: A prepared base or bottom of a trench or excavation on which a pipe or its structure is supported.

Biochemical Oxygen Demand (BOD): The rate at which microorganisms use the oxygen in water or wastewater while stabilizing decomposable organic matter under aerobic conditions.

Bucket machine: A powered winch machine designed for operation over a manhole. The machine controls the travel of buckets used to clean sewers, a mechanical type of cleaning.

Cardiopulmonary Resuscitation (CPR): Reviving the heart and lungs.

Centerline: Center of the width of a public or utility easement or roadway.

Channel: Provides a transition of wastewater from one or more inlet pipes to the outlet line. Located in a manhole.

Clean Water Act (CWA): The federal Clean Water Act sets the framework for the imposition of industrial wastewater control programs on municipalities and the regulation of industrial users. Sections 307(b) and (c) of the Clean Water Act set forth the authority for U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to POTWs.

Coagulate: The use of chemicals that cause very fine particles to clump together in larger particles.

Combination Cleaner: Jet/vacuum trucks than can clean sewers and vacuum up debris simultaneously. A hydraulic type of cleaning.

Compaction: Tamping or rolling of a material to achieve a surface or density that is able to support predicted loads.

Cone: The part of a manhole that tapers up from the barrel to a manhole cover. Can be either of two types, concentric and eccentric.

Confined-Space: A space that is large enough and so configured that an operator can enter and perform assigned work and has limited or restricted means for entry or exit, potentially contains toxic gases, and is not designed for continuous occupancy.

Engulfment: The surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

Excavate: To dig a trench, cavity or hole for or with access to install pipe or other structures.

Hydrogen Sulfide Gas (H_2S): A gas with a rotten egg odor. This gas is produced under anaerobic conditions. H_2S is particularly dangerous because it dulls the sense of smell after prolonged exposure and because the odor is not noticeable in high concentrations. The gas is very poisonous to the respiratory system and is very explosive and flammable.

Infiltration: The water entering a sewer pipe including service connections from the ground. Defective pipes, pipe joints, connections or manhole walls are a few of the common location where infiltration can occur.

Invert: The lowest point of the channel inside a pipe or manhole.

Jetter (High Velocity Cleaner): A machine designed to remove grease and debris from smaller diameter pipe with jets of high velocity water. Also called a “Jet Cleaner”, “Jet Rodder”, “Hydraulic Cleaner”, or “High Pressure Cleaner”.

Line Cleaning: Collection system pipeline maintenance operations using hydraulic or mechanical cleaning methods.

Material Safety Data Sheets (MSDS): A document which provides pertinent information and a profile of a particular hazardous substance or mixture. The document is provided by the manufacturer of the substance or mixture.

Oxygen Deficiency: An atmosphere containing oxygen at a concentration of less than 19.5% by volume.

Parachute: A device used to catch wastewater flow to pull a float line between manholes.

Pathogen: A bacteria, virus, or cyst found in wastewater that can cause disease in a host.

Penetrator Nozzle: A type of high pressure water nozzle that is designed to penetrate blockages in sewer pipes, usually used with Jet Rodders or Combination Machines.

Porcupine: A type of mechanical tool used with a mechanical rodder. Its function is to scour lines of light build up in conjunction with water flushing of sewer lines.

Root Saw: A type of mechanical tool used with a mechanical rodder. Its function is to cut through, by sawing action, root masses in a pipe.

Sand Nozzle: A type of high pressure water nozzle that is designed to remove large amounts of sand or other light sediment in sewer pipes. Usually used with Jet Rodders or Combination Machines.

Sanitary Sewer Overflow (SOS): A discharge of wastewater from a location that is not authorized by a NPDES permit. A sanitary sewer overflow may be the result of a pipeline blockage, hydraulic overloading of pipelines or pump stations, equipment malfunctions, or damage to conveyance systems.

Shoring: Material such as boards, planks or plates, and hydraulic jacks used to hold back soil around trenches and to protect workers in a trench from cave-ins.

Square Bar Corkscrew: A type of mechanical tool used with a mechanical rodder. Its function is to remove roots and rigid obstructions in a pipe by cutting and tearing action.

Vitrified Clay Pipe (VCP): A type of pipe used in wastewater collection systems. Vitrified clay pipe is rigid and resistant to internal and external attack from acids, alkalies, gases, solvents and other materials found in wastewater.

Volatile Solvents: A solvent that is capable of being evaporated or changed to a vapor at relatively low temperatures.

Wet Well: A compartment or tank in which wastewater is collected. The suction pipe of a pump may be connected to the wet well or a submersible pump may be located in the wet well.

Worker Right-To-Know Law: Federal and State laws governing worker health and safety in the work place.

Management and Supervision Terms

Ability: The quality of being able to perform; a natural or acquired skill or talent.

Accident: Unplanned or uncontrolled event in which action or reaction of an object, material, or person results in personal injury.

Accountability: Non-assigned liability for the manner in which an organizational obligation held by a supervisor is discharged, either personally or by subordinates.

Active listening: Conscious process of securing information through full attention, intent listening, and alert observation.

Affirmative Action: In-company program designed to remedy current and future employment inequities.

Americans with Disabilities Act (ADA): Prohibits employment discrimination based on a person's mental or physical disability.

Appraisal interview: Meeting held between a supervisor and an employee to review performance rating and, using the evaluation as a basis, to discuss overall quality of work performed, and methods of improvement, if necessary.

Arbitration: Labor dispute or employee grievance settlement by an impartial umpire selected through mutual agreement by organization and worker's union.

Attrition – Gradual reduction in a work force due to natural events and causes, e.g. - retirement, death, resignation, as opposed to planned reductions, e.g.- discharges, layoffs, early retirement.

Authority: The power needed to do a specific job or to carry out one's responsibilities usually handed down from immediate

bosses or superior.

Body language: Nonverbal body movements, facial expressions and/or gestures that project or reveal underlying attitudes and sentiments.

Budget: Plan, or forecast, especially of allowable expenses in operation of a department.

Budgetary control: Planning and reporting system incorporating standards for operating conditions and results as well as costs and expenses, within a single document.

Certification Exam: An examination administered by a state or professional association that candidates take to indicate a level of professional competence.

Chain-of-Command: Formal channels in an organization that distributes authority from top down.

Code of Federal Regulations (CFR): A publication of the United States Government that contains all of the proposed and finalized federal regulations, including environmental.

Collective bargaining: Process of give-and-take engaged in by management and collective employees representatives to reach formal, written agreement about wages, hours, and working conditions.

Communication process: Giving and receiving information and understanding such as between a supervisor and an employee, leading to a desired action or attitude.

Computerized Maintenance Management System (CMMS): A computerized system to assist with the effective and efficient management of maintenance activities through application of computerized elements including: work orders, routine standard jobs, bills of materials, application parts, and lists of all numerous other features.

Competition: Relatively healthy struggle among individuals or organizational groups to excel in striving to meet mutually beneficial goals.

Conflict: Disruptive clash of interests, objectives, or personalities between individuals or groups within an organization.

Control: To exercise authoritative influence over; the authority or ability to manage and/or direct.

Cost-benefit analysis: Technique for weighing pros and cons of alternative actions, in which both intangible benefits as well as costs are assigned dollar values.

Cost variance report: Listing of allowable expenses compared with actual expenses incurred.

Decision-making: Part of the problem-solving process that entails evaluation of alternative solutions and a choice of an effective action.

Delegation: The act in which power is given to another person in the organization to accomplish a specific job.

Differential treatment: Act of treating a minority or protected group member differently from other applicants or employees.

Discipline: Imposition of a penalty by management on an employee for infraction of a rule, regulation, or standard in such a manner as to encourage more constructive behavior.

Discrimination: Managerial action or decision based on favoring or disfavoring one person or group member over another on the basis of race, color, ethnic or national origin, sex, age, handicap, or Vietnam era war service, or union membership.

Division of work: Principle that performance is more efficient when a large job is broken down into smaller, specialized tasks.

Due process: Employee's legal entitlement to a fair hearing, usually before an impartial party and with appropriate representation, before discipline can be metered out.

Employee turnover: Measure of how many people come to work for an organization and do not remain employed by that organization, for whatever reason.

Ergonomics: Study of how workers react to their physical environment; used in design of more comfortable and productive workstations.

Equal Employment Opportunity (EEO): System of organizational justice, stipulated by law, that applies to all aspects of employment; intended to provide equal opportunity for all members of the labor force.

Feedback: Process of relaying measurement of actual performance back to an individual or unit so that action can be taken to correct, or narrow, the variance.

Geographical Information System (GIS): An integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, images, and other resource data that are geographically referenced.

Gantt chart: Chart that enables a planner to schedule tasks in the most productive sequence that also provides a visual means for observing and controlling progress.

Grievance: Job-related complaint stemming from an injury or injustice, real or imaginary, suffered by an employee for which relief or redress from management is sought.

Grievance procedure: Formalized, systematic channel for employees to follow in bringing complaints to the attention of management.

Hazard: Potentially dangerous object, material, condition, or practice present in the workplace, to which employees must be alert and from which they must be protected.

Hostile Work Environment: As applied to harassment, offensive speech or unwelcomed conduct that is severe or persuasive enough to create an abusive, antagonistic, or inhospitable work place.

Information Management System (IMS): System comprised of data processing devices, programs, and people, that collects, analyzes, exchanges, and delivers information to an organization in such a manner as to aid managers in making best possible decisions.

Information: Dates past or present facts, observation or conclusions collected in numbers and words that have been selected, arranged, and analyzed (processed) to make it useful for a specific human (managerial) activity.

Injury Illness Prevention Plan: Plan required by California Senate Bill (SB) 198 to establish, implement, and maintain an effective program helping assure employee safety while on the job. It includes eight elements: management assignments and responsibilities, safety communications system with the employees, system assuring employee compliance with safe working practices, scheduled inspections and compliance system, accident investigation, health and safety training and instruction, and record-keeping and documentation.

Job breakdown analysis: Segmentation of a job into key elements, or steps, of which an employee must perform, induce, or supervise an action that advances work toward completion.

Job evaluation: Systematic technique for determining job worth, compared with other jobs in an organization.

Just cause: Reason for a disciplinary action that is accurate, appropriate, well founded, deserved and meets the test of prior notification of unacceptable behavior and its penalty.

Knowledge: Information that can be learned

from reading, listening to an expert, or keenly observing a situation; often a prerequisite to skill development.

Management: Process of obtaining, deploying, and utilizing a variety of essential resources in support of an organization's objectives.

Management by objectives (MBO): Planning and control technique where a supervisor and their immediate superior agree on goals to be attained and/or standards to be maintained.

Management development: Systematic program for improving knowledge, attitudes, and skills of supervisors and managers.

Management principles: Set of guidelines established for carrying out the management process.

Management process: General sequence of five unique functions; planning, organizing, staffing, directing or activating, and controlling, provided by managers for any organization.

Manager: Individual who plans, organizes, directs, and controls work of others in an organization.

Material Safety Data Sheets (MSDS): Provides information about manufactured chemicals as required by the Hazard Communication Rule (HCR).

Mentor: Knowledgeable, often influential, individual who takes an interest in, and advises, another person concerning that person's career.

Morale: Measure of extent of voluntary cooperation demonstrated by an individual or work group and of the intensity of desire to meet common work goals.

Motivation: Process that impels someone to behave in a certain manner in order to satisfy highly individual needs.

Networking: Informal process of getting to know, and create confidence among others who, through mutual exchange, help advance one's career.

Non-managerial employees: Workers who receive direction from managers, who perform specific, designated tasks, and who are responsible only for their own performance.

Organizing: Deciding who does what work and delegating authority to the appropriate person.

Organization: Structure derived from systematically grouping tasks to be performed and from prescribing formal relationships that strengthen the ability of people to work together more effectively.

Performance appraisal: Formal and systematic evaluation of how well a person is performing their work and fills an appropriate role in the organization.

Penalty: Punishment or forfeiture imposed by management on an employee as discipline.

Personality – An individual's unique way of behaving and interpreting events and actions of others.

PERT Chart: Graphic technique for planning a project in which a large number of tasks must be coordinated by showing the relationship between tasks and critical bottlenecks that may delay progress towards completion.

Policies: Broad guidelines, philosophy, or principles which management establishes, then follows, in support of organizational goals.

Procedures: Methods, prescribed by management, for the proper and consistent forms, sequences, and channels to be followed by individuals and units of an organization.

Productivity – Measure of efficiency that compares operational output value with cost of resources used.

Progressive Discipline: Providing increasingly

harsh penalties for substandard performance or broken rules as the condition continues or the infraction is repeated.

Quid pro quo: an equal exchange or substitution; as applied to harassment- when a supervisor threatens to fire or not promote an employee if they do not provide sexual favors in return.

Regulations: Special rules, orders, and controls set forth by management restricting the conduct of units and or individuals within an organization.

Reprimand: Severe expression of disapproval or censure by management of an employee, usually written as well as oral, and retained in an employee's personal file.

Responsibilities: Those duties one is held accountable for.

Responsibility: Duty or obligation to perform a prescribed task or service or attain an objective.

Reverse discrimination: Notion that implementation of affirmative action deprives qualified members of non-protected groups their rightful opportunities.

Satisfaction: State that exists when motivating factors - such as interesting and challenging work, full use of one's capabilities, or recognition for achievement - are provided.

Schedules: Detailed assignments dictating how facilities, equipment, and/or individuals are used, according to times and dates, in accomplishment of organizational objectives.

Sexual Harassment: Unwanted sexual advances, requests for sexual favors or other visual, verbal, or physical conduct of a sexual nature which is conditioned upon an employment benefit, unreasonably interferes with an individuals work performance or creates an offensive work environment.

Skill: The capacity to perform a job related action by blending relevant knowledge and physical or perceptual ability.

Specification: Collection of standardized dimensions and characteristics pertaining to a product, process, or service.

Stereotype: Characterization of an individual on the basis of a standardized, oversimplified view of characteristics believed to be held in common by a group to which the individual is assumed to belong.

Supervisor: Manager who is in charge of, and coordinates, activities of a group of employees engaged in related activities within a department, section, or unit of an organization.

Suspension: Temporary removal by management of an employee privilege (such as the right to report to work and receive pay for it) until proper actions have been determined and imposed.

Time budget – Charting technique for planning the systematic distribution of a supervisor's time.

Theory X: Negative approach to human relations in which a supervisor presumes most people don't like to work and thus need to be pushed or threatened.

Theory Y: Positive approach to human relations whereby a supervisor presumes that, given meaningful work, most people will try hard to achieve, especially when there is an opportunity to improve their self-regard.

Tolerance: Permissible deviation, or variance, from a standard.

Type A individual: Person characterized by high standards of achievement and an urgency to attain them, who is especially susceptible to stress.

Unfair labor practices: Practices engaged in by management or labor unions that are judged

by federal labor law to be improper, especially when they interfere with the right to organize or discriminate against labor union activities.

Unity of Command: Principle that each individual should report to only one boss.

Unity of Direction: Principle that there should be a single set of goals and objectives that unites the activities of everyone in an organization.

Variance: Gap, or deviation, between actual performance, condition, or result and a standard or expected performance, condition, or result.

Warning: A reprimand so worded as to give formal notice to an employee that repetition of a particular form of unacceptable behavior will draw a penalty.

Worker's compensation: Financial reparations or awards granted by an employer to an employee who has suffered an on-the-job injury or illness that is judged to have permanently restricted the employee's earning capacity.

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Appendix C

Common Acronyms and Abbreviations

AC Power: alternating current

AC: acre

AF: acre-feet

AF: acre-foot (feet)

AFY: acre-foot per year

AMSA: Association of Metropolitan Sewerage Agencies

ANSI: American National Standard Institute

APHA: American Public Health Association

ASCE: American Society of Civil Engineers

ASME: American Society of Mechanical Engineers

ASTM: American Society for Testing and Materials

AWWA: American Water Works Association

BECP: Business Emergency and Contingency Plan

BTU: British thermal unit

C: Celsius

Cal OSHA: California Occupational Safety and Health Act

CalEPA: California Environmental Protection Administration

CCR: California Code of Regulations

cf: cubic feet (foot)

CFR: Code of Federal Regulations

cfs: cubic feet per second

CH_4: Methane

CIU: Categorical Industrial User

CM: common mode

CMOM: Capacity Management, Operations, and Maintenance

CPU: central processing

CRWA: California Rural Water Association

CSP: confined-space permit

CT: current transformer

CWA: Clean Water Act

CWEA: California Water Environment Association

DOHS: California Department of Health Services

DV/DT: (DV/DT) The change in voltage per change in time.

DWF: dry weather flow

DWR: Department of Water Resources

EIS: Environmental Impact Statement

EMF: electromotive force or voltage

EPA: U.S. Environmental Protection Agency

F: Fahrenheit

ft: feet (foot)

ft^2: square foot

ft^3: cubic feet

gal: gallon

GFI: ground fault interrupter

GPD: gallons per day

GPM: gallons per minute

GTAW: gas tungsten arc welding

H_2S: hydrogen sulfide

HCP&ERP: Hazard Communications Program and Emergency Response Plan

hp: horsepower

Hz: Hertz
IIPP: Injury and Illness Prevention Plan

IML: Interface Management Language

K: Kilo, a prefix meaning 1000

KVA: kilovolt amperes

kw: kilowatt

kwh: kilowatt hour

L: liter

lb: pound

M: Mega, a metric prefix meaning 1,000,000

m: meter

MA: millamps

MG: million gallons

mg: milligram

mg/L: milligrams per liter

mgd: million gallons per day

min: minute

MIS: Manufacturing Information System

mL: milliliter

MMI: Man Machine Interface

MOP: Manual of Practice

MPN: most probably number

MSDS: Material Safety Data Sheets

N: normal

NEPA: National Environmental Policy Act

NOCA: National Organization for Competency Assurance

NPDES: National Pollutant Discharge Elimination System

NPSH: net positive suction head

NTU: nephelometric turbidity unit(s)

O&M: operation and maintenance

OCT: Operator Certification Test (State of California)

OMR: operations, maintenance, and

replacement

OOC: Office of Operator Certification (SWRCB)

OSHA: Occupational Safety and Health Administration/Act

P: pico, a metric prefix meaning on million millionth

PC: personal computer

pH: potential of hydrogen

PI&D: piping and instrumentation diagram

PLC: Programmable Logic Controller

POTW: Publicly Owned Treatment Works

PPB: parts per billion

PPE: Personal Protective Equipment

PPM: parts per million

prct: percent

psi: pound per square inch

PSIG: pounds per square inch gage

PVC: polyvinyl chloride (pipe)

QA/QC: quality assurance/quality control

RCP: reinforced concrete pipe

RFI: adio Frequency Interference

RMS: root mean square

RWQCB: Regional Water Quality Control Board (State of California)

SCADA: supervisory control and data acquisition

SCR: semiconductor, or silicon controlled rectifier

sec: second

SI: System Internationale D'Unites (metric units)

SSO: sanitary sewer overflow

SWRCB: (California) State Water Resources Control Board

TAC: Technical Advisory Committee

TCP: Technical Certification Program

TU: turbidity unit

U: micro, a metric prefix meaning one millionth

UPS: uninterruptible power supply

USEPA: United States Environmental Protection Agency

V: volt

VAC: volts of alternating current

VCP: vitrified clay pipe

VFD: variable frequency drive

VOM: volt Ohm meter

W: watt

WAN: wide area network

WEF: Water Environment Federation

WRP: water reclamation plant

WWF: wet weather flow

WWTF: wastewater treatment facility

WWTP: wastewater treatment plant (same as POTW)

yr: year

CWEA is pleased that you have purchased this book.

We want to remind you that this book is one of many resources available to assist you, and we encourage you to identify and utilize the other resources in preparing for your next test.

Your comments, questions, and suggestions are welcome.

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