Certification Examination

Study Guide

Environmental Compliance Inspector

Grade I

CALIFORNIA WATER ENVIRONMENT ASSOCIATION

Environmental Compliance Inspector Grade I 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.

Please send comments, questions, and suggestions to:
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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, you are welcome to bring your 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 postpone 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 two (2) weeks after the approved testing window. Full refunds, less the administrative fee*, 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 sults 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 the Candidate Feedback Review Screen during the exam. Candidate feedbacks will be evaluated and appropriate adjustments made to the test content. Candidates submitting feedback will not be contacted in regards to the appeal.

Qualifying for the Test

Specific experience and educational background for Grade I Environmental Compliance Inspector certification is unnecessary. Completing the Application for Technical ertification, paying the appropriate application fee, and passing the written test are the only requirements. However, it is *recommended* that Grade I candidates have at least one year of wastewater system maintenance experience. Many candidates without such experience have difficulty successfully completing the written test.

Essential Duties of Inspectors include:

- Uses appropriate sampling locations and procedures; collects representative samples in accordance with the District's quality assurance program of wastewater and water from industrial, commercial, residential, and institutional sources, various clarifiers or sumps, and storm sewers; completes appropriate documentation, including chain-of-custody documentation; and performs field tests or laboratory tests on samples collected.
- Observes and records field conditions, flow meter readings, pH, ORP, selective ion, explosivity, and other field test results.
- Uses, cleans, inspects, maintains, and repairs sampling equipment, meters, and test equipment.
- Inspects pretreatment facilities and processes of industrial and commercial establishments for compliance with wastewater discharge ordinance and permit conditions.
- Inspects industrial and commercial businesses for compliance with storm runoff and pollution prevention requirements.

- Assists in call-outs and the investigation and tracing of the sources of illegal or nuisance waste discharges entering the storm water or wastewater collection system.
- Collects information for assessing fees from industrial and commercial establishments.
- Check grease traps, interceptors, and clarifiers.
- Records data and observations. Provides input and assistance in the preparation of a variety of manual and computerized written, oral, tabular, and graphic reports; updates filed inspection records; and tabulates, calculates and prepares data for sewer service charges.
- Supports customer service activities; responds to questions of a limited variety and scope after receiving specific instruction; refers inquiries to appropriate personnel; interacts cooperatively with internal and external customers and provides feedback to appropriate staff.
- Learns and keeps current on pertinent information and developments in environmental compliance functional areas; assists in the implementation of state, federal, or local requirements to support appropriate programs.
- Learns and observes proper safety pre cautions, rules, regulations, and practices; maintains equipment, materials, and work site in proper and safe condition in accordance with policies and procedures
- Learns how wastewater is treated and how it can be impacted by industrial waste.

Section 3

Skill Sets

The Grade I Environmental Compliance Inspector (Inspector) has many responsibilities. Primary responsibilities include assisting the local authorities in protecting their wastewater collection and treatment systems, and the health and safety of their workers. Additionally, Inspectors' responsibilities frequently include monitoring and enforcement of local storm water, pollution prevention, and hazardous waste programs. The following sections give a concise description of the practical skills Inspectors must possess to pass the certification test. These sections expand on the KSA contained in the candidate handbook for Grade I.

References for further study of the Grade I skill sets are included in Section 6. Table 3-1, presented at the end of this section, cross-references each skill set with a specific chapter, section, or page of applicable references to assist the candidate to better understand the subject matter.

Skill Set 1 Basic Scientific Principles

Inspectors must have a working knowledge of basic chemistry, biology, and physics, especially as related to water and wastewater chemistry, and chemistry encountered in industrial processes. They are also familiar with the fundamentals and terms of the biological treatment processes used at most publicly owned treatment works (POTW), and the various compounds that can inhibit or hinder biological treatment processes. A further discussion of each topic area is included below.

1.1 Chemistry

Inspectors should have a good familiarity with chemical principles equivalent to a high school graduate or college freshman grade level, especially as it pertains to water and wastewater chemistry. This includes atomic weight of elements, and gram-molecular weight or moles of substances. Familiarity with the fundamentals of pH, acidity, alkalinity, oxidation-reduction, and other applications commonly found in water chemistry is important. Inspectors should be able to balance common chemical equations used in water chemistry and use them to solve problems encountered in pretreatment inspection work. Problems may include basic pretreatment operations, including pH neutralization, determining chemical feed rates, and chemical storage requirements. Solving these problems requires knowledge regarding molarity and normality, and other basic chemistry concepts. Familiarity with the common names of generally used treatment chemicals such as soda ash, caustic soda, and quicklime is also recommended.

1.2 Mathematics and Physics

Inspectors should be well versed in the basic arithmetic discussed in Section 4, including decimals, proportions, and metric measure. They should be able to perform unit conversions to solve various mathematical problems. These include conversion of volume to weight or mass. Solution results must be expressed in proper units such as milligrams per liter, gallons per day, cubic feet, etc. Inspectors should be familiar with basic wastewater collection and physical treatment processes and be able to solve common math problems applied to these areas. Math problems may include flow equalization, metals precipitation, settling, detention times, pollutant concentrations and mass. For example, Inspectors should be able to calculate volumes of tanks and containers, convert units as required, and determine required spill-containment volumes for chemical storage areas.

1.3 Biological Treatment Principles

Inspectors should be familiar with the typical characteristics of domestic wastewater treated in POTWs. They should have a basic understanding of the principles, terms and analytical methods associated with biological treatment of wastewater at the POTW. This includes measurement of organic content of wastewater, such as biochemical oxygen demand (BOD) and chemical oxygen demand (COD), and the various constituents controlled in biological treatment systems such as dissolved oxygen and nitrogen. They should also have a basic knowledge of the various types of industrial chemicals that can cause upsets to biological treatment systems. Inspectors should be familiar with the fundamentals of hydrogen sulfide generation in sewage collection systems, including the potential health and safety, and maintenance concerns.

Skill Set 2 Sampling and Analysis

Inspectors must understand the basic principles of sample collection, including grab sampling, time composite, and flow composite sampling, and the types of equipment associated with each sampling technique. They should be familiar with methods and techniques of sampling in wastewater collection systems as well as discharges from industrial users. Mathematics involved can include proportioning samples from several different discharges to create a flow-proportioned composite sample. Inspectors should also be familiar with the proper use of sample containers, preservatives and preservation methods, and maximum sample holding times for analysis of common wastewater constituents. Inspectors must be knowledgeable of the procedures required for legally enforceable sampling and analytical results. These include the use of chain-of-custody documents and other procedures to ensure that results are valid.

Skill Set 3 Wastewater and Industrial Processes and Equipment

Inspectors must be familiar with the principles and operation of POTWs and wastewater collection systems, including sanitary and combined sewers, and the potential impacts of industrial discharges on these systems. They should also be familiar with basic industrial processes and wastewater pretreatment systems. Successful Inspectors have a good grasp of the various types of industrial and commercial facilities that discharge into municipal wastewater collection systems and the industrial or commercial processes that generate this waste. The types of industries that will be inspected are those regulated under the sewer ordinance administered by the local authority.

3.1 Regulations

Inspectors should be familiar with the federal Clean Water Act, which creates the framework for industrial wastewater control programs. The heart of the national pretreatment program is a set of rules and regulations known as the General Pretreatment Regulations. These regulations are codified in Title 40 of the Code of Federal Regulations, Section 403 (40 CFR 403). These regulations establish the responsibilities of the federal, state and local governments, industry, and the public to implement the national pretreatment program. They also regulate the type and quantity of pollutants which may be discharged to a POTW. The General Pretreatment Regulations regulate pollutants which may: 1) pass through the POTW treatment system untreated or partially treated, 2) interfere with the POTW treatment works, and/or 3) contaminate the POTW sludge with respect to the sludge disposal method employed by the POTW.

Inspectors should also know the eight generally prohibited discharges and the legal authority POTW's have to regulate industrial users as established in 40 CFR 403.8 (f)(1). These include:

- local discharge limits

- issuing discharge permits
- requiring industrial users to install necessary technology to meet pretreatment standards
- carrying out all necessary inspection, surveillance, and monitoring procedures needed to determine compliance with pretreatment requirements
- authority to obtain remedies for non-compliance including administrative orders, civil penalties, and criminal penalties

A Grade I Inspector's essential duties may include inspecting industrial and commercial facilities for compliance with storm water runoff and pollution prevention requirements. Therefore, basic knowledge of federal storm water discharge regulations is needed. These are codified in 40 CFR 122.26 as part of the National Pollutant Discharge Elimination System (NPDES). Candidates should know the definition of storm water, illicit discharge, significant materials, and storm water discharge associated with industrial activity. They should know the general categories regulated under 40 CFR 122.26, including municipal separate storm sewer systems, industries, and construction sites. They should also know the difference between individual and general NPDES storm water discharge permits.

3.2 Flow Monitoring Equipment

Inspectors should be familiar with the various types of flow measuring devices used for industrial wastewater monitoring and the flow measuring principles associated with each device. These include:

- Closed full pipe flow meters such as magnetic, turbine, doppler, and Venturi
- Open channel flow measuring devices, such as:
    - Rectangular, Cipolletti, and V-notch weirs
    - Flumes, such as Parshall, and Palmer-Bowlus flumes

Inspectors should be able to recognize these flow measuring devices in the field and be able to take instantaneous and totalized flow readings from them. They should also be familiar with temporary methods of flow measurement. These may include using the Manning equation for calculating flow in open channels, or volumetric methods such as use of tanks, containers, or stopwatch and bucket.

3.3 Mechanical Equipment

Grade I Inspectors have basic knowledge of the mechanical equipment used in wastewater and industrial waste treatment, including: pumps, mixers, flocculators, chemical feed systems, settling tanks and clarifiers, oil/water separators, filtration and membrane systems, sludge treatment and dewatering systems, and emergency alarm and back-up systems.

Inspectors should know the operating theory behind the various types of pumps used in wastewater treatment, including centrifugal and positive-displacement, and pump control systems such as level controls. Centrifugal pumps are normally used to convey wastewater and may be either submersible or non-submersible. Inspectors should know the various types of positive-displacement pumps, such as diaphragm pumps, and their common uses in wastewater treatment such as conveying sludges, and chemical feed systems.

3.4 Industrial Processes

Inspectors should become familiar with the industrial processes that generate industrial wastewater of concern to the POTW. Many times this will include those industrial dischargers classified as categorical users regulated under the Federal pretreatment regulations. These include electroplating and metal finishing processes, printed circuit board and semiconductor manufacturing, inorganic and organic chemical manufacturing, petroleum and petro-chemical industries to name a few. High strength wastewater with high total suspended solids (TSS) and organic content is often discharged from various food processing facilities such as dairies, bakeries, and meat packing plants. Inspectors should become familiar with the common pollutants of concern (POC) discharged from the various categories of industries and industrial processes. The negative affects of such pollutants on the POTW should also be understood including POTW process inhibition, pass through, sludge quality, and safety concerns.

3.5 Industrial Wastewater Treatment Processes

Basic industrial wastewater pretreatment includes the physical-chemical processes such as flow equalization, settling, oil/water separation, precipitation, coagulation, flocculation, pH neutralization, oxidation, reduction, and filtration. Biological processes are also used for wastewater from the food processing, petrochemical, and pharmaceutical industries. Inspectors should become familiar with the conventional pretreatment processes used in the development of the federal categorical pretreatment standards.

Skill Set 4 Safety and Traffic Control

4.1 General

To successfully achieve a Grade I certification, Inspectors should have the ability to recognize and identify hazards and hazardous situations encountered above and below ground in collection systems and industrial operations. A full knowledge of safety procedures and prevention techniques is also needed.

Additionally, it is necessary to be familiar with and understand safety laws, rules, and regulations as they apply to Inspectors, their co-workers, and the public. The ability to interpret and understand the worker right-to-know law is also necessary. Common confined space work by Inspectors includes maintenance or manhole entry for wastewater collection system sampling.

4.2 Traffic

Grade I candidates should be familiar with and understand the elements of traffic control. Awareness and comprehension of the hazards of working in roadways as they pertain to Inspectors, co-workers, drivers, and pedestrians is imperative. They should have a general understanding of traffic safety equipment and its proper use. The ability to identify basic flagging equipment, and understand proper procedures for its use is also necessary.

4.3 Vehicles and Equipment

Inspectors are expected to understand how to perform appropriate safety checks on vehicles, and possess a thorough knowledge and understanding of traffic laws and defensive driving techniques. For safety purposes, the proper application and operation of the various vehicles, tools and equipment used in collecting samples in the street or at an industrial facility must be understood.

4.4 Confined-Space

It is important to know what confined spaces are and understand the definitions. There are different classifications of confined spaces and it is important to know what the differences are between classes. A working knowledge of the confined space permit process, entry procedures and rescue operations, as well as terminology, is necessary. Common confined space work by Inspectors includes maintenance hole or manhole entry for wastewater collection system sampling.

Knowledge and understanding of confined space safety rules, requirements, and regulations, as well as accident/injury prevention techniques, is important. It is necessary to be aware of and understand the hazards and effects of confined-space work, and the responsibilities of those working and supervising work in confined spaces. Inspectors need to be able to recognize confined space safety equipment and understand its proper function and operation.

4.5 Chemical and Biological Hazards

There are numerous chemical and biological hazards that may be encountered during environmental compliance inspection work. A basic knowledge of these substances, and their hazardous potential should be learned. Inspectors should be knowledgeable of the policies and procedures for prevention of, and protection from, these hazards. Inspectors should be able to identify the types of personal protection equipment commonly used in inspection work, and understand their proper use.

4.6 Hazardous Atmosphere

It is important to understand what hydrogen sulfide is and its impact in wastewater collection systems. Its causes, as well as its hazards and effects to both personnel and the collection system should be fully understood. It will also be necessary to identify the causes of hydrogen sulfide generation and the methods used to control this substance.

Inspectors should also know the purposes of air or atmosphere safety monitoring, including monitoring for specific gases or indicators such as carbon dioxide (CO), oxygen (O_2), hydrogen sulfide (H_2S), and the Lower Explosive Limit (LEL).

4.7 Material Safety Data Sheets

Any hazardous chemical product used within the wastewater field has Material Safety Data Sheets (MSDS). These documents provide valuable information about potentially hazardous chemicals used on the job. Inspectors should know what MSDS are, the information they contain, and understand their use.

Table 3-1 Grade I Environmental Compliance Inspector						
Primary References[a]						
No.	Skill Set	Developing Source Control Programs for Commercial and Industrial Wastewater	Industrial User Inspection and Sampling Manual for POTWs	Pretreatment Facility Inspection: A field Study Training Program	Industrial Waste Treatment	Treatment of Metal in Waste-streams
1	Basic Scientific Principles					
1.1	**Chemistry**			Appendix III Sections K, N-Q		Appenndix III
1.2	**Mathematics and Physics**			Appendix II Sections A-J		Appendix II and III
1.3	**Biological Treatment Principles**				Volume 2 Chapter 3	
2	Wastewater Sampling and Analysis					
	Wastewater Sampling and Analysis	Chapters 9 and 11	Chapter III	Chapter 6		Section 7.24
3	Wastewater and Industrial Process Equipment					
3.1	**Regulations**	Chapter 1 Pages 5-10 Chapters 2, 5	Chapter I Pages viii-xvi	Chapters 1, 3	Volume 1 Chapter 3	
3.2	**Flow Monitoring Equipment**	Chapter 10	Chapter III Pages 88-95	Chgapter 7	Volume 16 Chapter 6	Section 7.25
3.3	**Mechanical Equipment**				Volume 2 Chapter 8	Chapter 7.39, 7.4-7.5
3.4	**Industrial Processes**	Chapter 4, Table 4-1 Pages 50-65		Chapter 8	Volume 1 Chapter 1.6, 5	
3.5	**Industrial Wastewater Treatment Processes**	Chapter 12	Appendix II	Chapter 9	Volume 1 Chapters 7-11	Chapters 5, 6

a. Complete reference information is provided in Section 6

Table 3-1 Grade I Environmental Compliance Inspector						
Primary References[a]						
No.	Skill Set	Developing Source Control Programs for Commercial and Industrial Wastewater	Industrial User Inspection and Sampling Manual for POTWs	Pretreatment Facility Inspection: A field Study Training Program	Industrial Waste Treatment	Treatment of Metal in Waste-streams
4	Safety					
4.1	**General**	Chapter 13 Pages 297-301	Chapter II	Chapter 5.0	Volume 1 Chapter 2 Glossary	Chapter 4
4.2	**Traffic**	Chapter 13 Pages 302-308	Chapter III Page 83	Chapter 5.1 Appendix B		
4.3	**Vehicles and Equipment**	Chapter 13 Pages 312, 315-316	Chapter III Pages 85-87	Chapters 5.4-5.6	Volume 1 Chapters 2.6-2.9	Chapters 7.39, 7.4-7.5
4.4	**Confined Space**	Chapter 13 Pages 306-310	Chapter III Pages 85-87	Chapter 5.2 Appendix D	Volume 1 Chapter 2.1	
4.5	**Chemical and Biological Hazards**	Pages 310-312	Pages 79-82 Appendix IV	Chapter 5.3	Volume 1 Chapters 2.10-2.111, 2.24	Chapter 7 Table 9
4.6	**Hydrogen Sulfide**		Page 81	Pages 296-297		
4.7	**Material Safey Data Sheets (MSDS)**				Volume 1 Chapter 2.10 Page 63	Chapter 3

a. Complete reference information is provided in Section 6

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 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.

Table 4-1 Environmental Compliance Inspector Equivalents and Formulas

Equivalents	Formulas	
3.785 liters/gallon	Volume of Rectangular Solid:	$V = LWH$
8.34 lbs/gallon	Volume of Cylinder:	$V = pR^2 H$
7.48 gallons/ft^3	Area of Circle:	$A = pR^2$
43,560 ft^2/acre	Area of Trapezoid:	$A = \frac{(B + b)}{2} H$
453.6 gm/lb	Area of Triangle:	$A = \frac{bh}{2}$
28.35 gm/oz	Manning Formula:	$Q = \frac{1.49 \times A \times R^{2/3} \times S^{1/2}}{N}$
12 inches/ft	*R = Hydraulic Radius*	*N = Friction Factor*
p= 3.14	*S = Slope*	*A = Area of Flow*

Table 4-2 Periodic Properties of Elements

Element	Symbol	Atomic Weight (grams/mole)
Aluminum	Al	27.0
Arsenic	As	74.9
Cadmium	Cd	112.4
Calcium	Ca	40.1
Carbon	C	12.0
Chlorine	Cl	35.5
Chromium	Cr	52.0
Copper	Cu	63.5
Fluorine	F	19.0
Hydrogen	H	1.0
Iron	Fe	55.8
Magnesium	Mg	24.3
Nickel	Ni	58.7
Nitrogen	N	14.0
Oxygen	O	16.0
Phosphorus	P	31.0
Potassium	K	39.1
Silver	Ag	107.9
Sodium	Na	23.0
Sulfur	S	32.1
Zinc	Zn	65.4

tunneeded units are cancelled out:

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

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. A 240-volt circuit has a resistance of 20 ohms. What is the amperage, in amps, and how much power, in kilowatts, is consumed?

   First, calculate the current in the circuit by the formula E = I x R. Solving for the unknown (current):

$$I = \frac{E}{R}$$

$$I = \frac{240\ \text{volts}}{20\ \text{ohms}} = 12\ \text{amps}$$

   Then calculate power consumption by formula:

   P (power in watts) = E (voltage) x I (current in amps)

$$P = 240\ \text{volts} \times 12\ \text{amps} \times \frac{1\ \text{kilowatt}}{1{,}000\ \text{watts}} = 2.88\ \text{kW}$$

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

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

4. An analyst filters 100 mL of primary effluent through a tared filter, dries the filter at 104°C, and weighs the filter again. Given the following information, what is the total suspended solids of the sample in mg/L.

   Tare weight 0.4150 g
   Dry weight 0.4275 g

   First calculate the weight of suspended solids:

0.4275 g - 0.4150 g = 0.0125 g in 100 mL

Then convert the desired units:

$$\frac{0.0125\ \cancel{g}}{100\ \cancel{mL}} \times \frac{1000\ \cancel{mL}}{L} \times \frac{1000\ mg}{\cancel{g}} = 125\ \frac{mg}{L}$$

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

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

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?

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

Math Skills

Successful candidates must be skilled in arithmetic 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 and understand the following calculations either manually or with a calculator:

1. Addition and subtraction of whole numbers and fractions.

2. Multiplication and division of whole numbers and fractions.

Algebra

Candidates should be able to perform basic *applied* algebra calculations such as solving for one unknown in one equation.

Example 1. A company is required to take a daily time-composite sample of its industrial wastewater discharge for analysis. The automatic sampler must take a discrete fixed-volume sample every 20 minutes for 24 hours. What is the minimum volume, in millimeters, that must be taken every 20 minutes to provide a 3 liter composite sample in 24 hours?

This is a ratio problem. The total volume of wastewater sample divided by the volume of each discrete sample is proportional to the total time of sampling divided by the time between discrete samples. The ratio is expressed as follows:

$$\frac{\text{Total Volume}}{\text{Discrete Volume}} = \frac{\text{Total Time}}{\text{Time Between Samples}}$$

The unknown is the discrete sample volume which must be expressed in millimeters. Construct the equation with the proper units so that all but the answer units cancel out. This will require converting all volume to millimeters and all time to minutes.

$$\frac{2\text{L} \times \frac{1{,}000\text{ mL}}{\text{L}}}{\text{Vol./sample}} = \frac{24\ \cancel{\text{hrs}} \times 60\ \frac{\cancel{\text{min}}}{\cancel{\text{hrs}}}}{20\ \cancel{\text{min}}\text{/sample}}$$

Solve the right side of the equation and multiply both sides by the unknown.

$$2{,}000\text{ mL} = 72\ \cancel{\text{samples}} \times \text{Vol./}\cancel{\text{sample}}$$

Then divide both sides by the number of samples to get the answer.

$$\frac{2{,}000\text{ mL}}{72\text{ samples}} = 41.7\text{ mL}$$

Although this problem requires basic arithmetic skills, it also requires knowledge and familiarity with sampling techniques to synthesize the given information and translate it into a mathematical equation to solve the problem.

Geometry

Candidates should be able to calculate circumference, find the area of a rectangle, circle, and the volumes of rectangular and cylindrical solids. Be prepared to apply these basic skills to work-related problems.

Example 2. A chemical storage tank 20 feet in diameter and 12 feet, 6 inches tall sits on a rectangular spill-containment pad with concrete walls. The containment pad is 35 feet long by 25 feet wide. How high must the containment walls be, in feet, to provide 100 percent containment of the tanks' contents?

This problem requires the ability to calculate the volume of one solid body, the tank, and calculate one dimension of another solid body, the spill-containment pad, to provide the same volume as the tank.

The tank is a cylinder and its volume can be calculated using the volume formula from Table 4-1.

Vol. = $\pi R^2 H$, where π = 3.14
R = 1/2 (Dia.) = 10 ft
H = 12.5 ft

To provide the answer in feet, volume should be calculated in cubic feet or ft^3.

$$\text{Vol.} = 0.785\ (20\ \text{ft.})^2 \times 12.5\ \text{ft} = 3{,}925\ \text{ft}^3$$

The volume of a rectangular solid body is given as:

Vol. = LWH, where L = 35 ft
W = 25 ft

Dimension "H", the wall height, is the unknown. Add the known values to the equation and solve for H.

$$H = \frac{\text{Vol.}}{LW} = \frac{3{,}925\ \text{ft}^3}{35\ \text{ft} \times 25\ \text{ft}} = 4.5\ \text{feet, or 4 feet, 6 inches}$$

This problem requires application of knowledge of basic geometry, arithmetic, and the ability to convert dimensions and units. In this case, three-dimensional (volume, ft^3) converted to one-dimensional (height, ft). It also requires basic knowledge of spill containment requirements. For example, if the tank leaks, the tank volume below the top of the spill-containment wall can be included in the total spill-containment volume.

Section 5

Diagnostic Test

Introduction

This section provides a diagnostic test for those studying for their Grade I Environmental Compliance Inspector certification to help determine their current knowledge level of wastewater chemistry, sampling, industrial and wastewater treatment processes, and safety. These questions represent the type of knowledge that may be required to successfully pass the CWEA certification test. Test questions are generally based on the information contained in the references (See Section 6 for a list of references). However, passing the example questions is not a guarantee of passing the test, as the test writers do not prepare the questions. Answers for this practice test and tips of where to find references for further study are located at the end of the test.

Skill Set 1 Basic Scientific Principles

1. An industry operating an 8-hour shift, 5 days per week, generates 100,000 gallons of wastewater per shift. Their pretreatment system has a capacity of 150 gallons per minute. How long must the pretreatment facility operate to process the wastewater generated each day?

   a. 15 hours
   b. 10.5 hours
   c. 11.1 hours
   d. 6.6 hours

2. What is the average detention time, in minutes, for a 40,000 gpd flow going through a 1,500-gallon interceptor?

   a. 54 minutes
   b. 27 minutes
   c. 15 minutes
   d. 40 minutes

3. What total volume of spill containment capacity in gallons is needed for the following tanks if a 12-inch rainfall occurs during a 24-hour period on a common 200-foot by 200-foot spill-containment pad? Assume 100 percent containment of all tank capacity is needed.

   Tank I: Cube, 6 ft wide, 6 ft long, and 6 ft high
   Tank II: Rectangular, 4 ft wide, 20 ft long, and 3 ft high
   Tank III: Cylindrical, 8 ft in diameter and 9 ft high

   a. 3,016,138 gallons
   b. 3,597,192 gallons
   c. 305,992 gallons
   d. 30,592 gallons

4. Alkalinity is reported as:

   a. alkalinity, mg/L phenolphthalein
   b. alkalinity, mg/L $CaCO_3$
   c. mg/L alkalinity
   d. alkalinity, mg/L acetic acid

5. A solution with a pH of 5 has a concentration of hydrogen ions that is how many times higher than a solution with a pH of 7?

   a. 2 times higher
   b. 10^{-5} times higher
   c. 10^{-2} times higher
   d. 100 times higher

6. The hardness determination measures:

   a. calcium and magnesium.
   b. calcium carbonate.
   c. alkalinity, corrosivity, and carbonates.
   d. calmagite.

7. An industry has a wastewater discharge of 10,000 gallons per day containing 5 mg/L of copper. What is the industry's mass emission rate of copper in pounds per day?

   a. 0.11 lb/day
   b. 0.05 lb/day
   c. 0.42 lb/day
   d. 0.50 lb/day

8. The BOD determination is an empirical test in which standardized laboratory procedures are used to:

   a. determine the relative dissolved oxygen in wastewaters, effluents, and polluted waters.
   b. determine the relative oxygen requirements of wastewaters, effluents, and polluted waters.
   c. determine the relative chemical oxidizers in wastewaters, effluents, and polluted waters.
   d. determine the relative organic compounds of wastewaters, effluents, and polluted waters.

9. A solution of ferrous chloride used at a pretreatment facility contains 30 percent ferrous chloride and has a density of 1.33 g/mL. How many grams of ferrous chloride are in one liter of the solution?

   a. 39.9 grams per liter
   b. 226 grams per liter
   c. 399 grams per liter
   d. 4,430 grams per liter

10. What is the normality of a sodium hydroxide solution of 25 ml if a 0.01 N sulfuric acid solution neutralizes 100 ml of the NaOH solution?

    a. 0.0025 N
    b. 0.064 N
    c. 0.25 N
    d. 6.4 N

11. An industry discharges 50,000 gallons per day of wastewater at a pH of 2.0. How many gallons per day of a 25 percent NaOH solution would be needed to maintain a discharge pH of 8.5?

    Molecular weight (M.W.) NaOH= 40.0

    a. 56 gallons
    b. 80 gallons
    c. 21 gallons
    d. 40 gallons

12. Sodium hydroxide is commonly referred to as:

    a. quicklime.
    b. soda ash.
    c. caustic soda.
    d. hydrated lime.

Skill Set 2 Sampling and Analysis

1. An industry has five sewer connections with the following discharge rates:

   1) 300 gpd, 2) 75 gpd, 3) 725 gpd, 4) 1,200 gpd, 5) 200 gpd

   A flow-weighted composite sample of 5 liters is desired. How many milliliters of sample from each connection should be composited?

   a. 1000, 1000, 1000, 1000
   b. 0.60, 0.15, 1.45, 2.40, 0.40
   c. 600, 150, 1450, 2400, 400

d. 120, 30, 290, 480, 80

2. You have been directed to collect a 12-hour flow proportional sample. Using the following data, select the volume of sample to be collected at 12:00 p.m. if a total sample volume of one liter is required.

Time	Flow, MG	Time	Flow, MG
6:00 a.m.	5.8	12:00 p.m.	9.0
7:00 a.m.	6.4	1:00 p.m.	9.6
8:00 a.m.	6.8	2:00 p.m.	8.8
9:00 a.m.	7.2	3:00 p.m.	8.2
10:00 a.m.	6.8	4:00 p.m.	7.6
11:00 a.m.	7.2	5:00 p.m.	6.8

a. 90 mL
b. 90.2 mL
c. 100 mL
d. 180 mL

3. An industry has a 36,000-gpd discharge in a sixteen-hour day. A composite sample of 2 liters is needed. The sampler is set to take 125 ml. Each time the pump is activated. For a flow proportional sample, at what gallon interval should the sampler activate to take a sample?

a. 2,200 gallons
b. 2,880 gallons
c. 2,150 gallons
d. 2,250 gallons

4. Lead acetate paper is used to determine the presence of:

a. chlorine.
b. hydrogen sulfide.
c. methane.
d. carbon monoxide.

5. A chain-of-custody form:

a. replaces the need for sample container labels.
b. must include field notes regarding sampling conditions.
c. is the ability to trace sample possession and handling from collection through analysis.
d. is the ability to trace sample handling techniques from preservation through extraction or digestion to analysis.

6. The following results for nickel, in mg/L, were obtained from daily composite samples. Select the correct mean, median, and range of values from the list.

6.7, 8.6, 9.0, 8.9, 8.9, 9.0, 8.5, 8.4, 8.7, 6.6, 8.8, 7.2, 8.5, 9.3, 8.9

a. Mean=8.4, median=8.7, range=2.6
b. Mean=8.4, median=8.7, range=2.7
c. Mean=8.4, median=8.8, range=2.7
d. Mean=8.5, median=8.6, range=2.4

7. In a normally distributed population of sampling data, what percent of the data points will fall within one standard deviation.

a. 99.7
b. 68.3
c. 50.0
d. 95.5

8. What kind of container and preservative is required for samples to be analyzed for oil and grease?

a. Plastic, Cool 4°C, H_2SO_4 to pH<2
b. Glass, Cool 4°C, NaOH to pH>12
c. Glass, Cool 4°C, H_2SO_4 to pH<2
d. Plastic, Cool 4°C, NaOH to pH>12

Skill Set 3 Wastewater and Industrial Processes and Equipment

1. Prohibited discharges from industrial users to POTWs, as stipulated in the Clean Water Act, are pollutants that:

a. create a fire or explosion hazard in the sewer or POTW.
b. have a pH lower than 6.0.
c. are released in such volume or strength as to inhibit chemical treatment at the POTW.
d. have a temperature that exceeds 100°F.

2. A significant industrial user can be defined as:

   a. discharging 20,000 gpd or more of process wastewater.
   b. contributes 2.0 percent or more of the POTWs hydraulic or organic (BOD, TSS) capacity.
   c. a federal categorical industrial user.
   d. a user that generates hazardous waste.

3. The following type of flow measuring device can be installed in a pipe flowing full:

   a. Cipolletti weir.
   b. Palmer-Bowlus flume.
   c. Venturi.
   d. Parshall.

4. Head measurements on weirs should be taken at a distance upstream of the weir of ____________ times the maximum expected head to be measured.

   a. 2
   b. 6
   c. 1.5
   d. 4

5. An example of a positive displacement pump is:

   a. diaphragm pump.
   b. progressing cavitation pump.
   c. turbine pump.
   d. submersible pump.

6. An ultrafiltration system removes _______ from wastewater.

   a. dissolved solids
   b. heavy metals
   c. salts
   d. suspended solids

7. Industrial plants producing wastes with a high suspended solids content include:

   a. breweries.
   b. textile dyehouses.
   c. oil fields.
   d. laundries.

8. High strength (high BOD) waste is a concern to a POTW because of the:

   a. toxic effects on treatment processes.
   b. effect on sludge quality.
   c. cost of treatment.
   d. safety of plant workers.

9. A major pollutant of concern (POC) from a printed circuit board shop is:

   a. mercury.
   b. cadmium.
   c. chromium.
   d. copper.

10. High pH wastewater is neutralized by adding:

    a. anhydrous ammonia.
    b. H_2SO_4.
    c. NaOH.
    d. $CaCO_3$.

11. Emulsified oil is commonly removed from wastewater by:

    a. gravity oil/water separator.
    b. aeration.
    c. settling tank.
    d. dissolved air flotation.

12. Heavy metals are commonly removed from metal finishing wastewater by:

    a. air stripping.
    b. chemical precipitation.
    c. activated carbon.
    d. oxidation.

13. Chemical feed pumps for pH control are automatically operated by:

    a. flow meter.
    b. pH meter.
    c. pH probe and controller.
    d. conductivity meter.

Skill Set 4 Safety and Traffic Control

1. "MSDS" is an acronym for what?

    a. Men Safely Delivering Sulfur Dioxide
    b. Material Safety Data Sheet
    c. Maintaining Safe Departmental Standards
    d. Mechanical Safety Device Standards

2. Safety hazards associated with hydrogen sulfide in sewer systems include:

    a. bad odors.
    b. corrosion of pipelines.
    c. toxic gasses.
    d. growth of pathogens.

3. A confined space is one that:

    a. has or may contain atmospheric, engulfment, design, or other serious health/safety hazard.
    b. is large enough to enter and work in, has a restricted entry/exit, and is not meant for continuous occupancy.
    c. is large enough to enter and work in and has a restricted entry/exit.
    d. has or may contain an atmospheric or engulfment hazard.

4. What is the danger of asphyxiation set point for oxygen on an atmospheric monitor?

    a. 20.9 percent
    b. 17.5 percent
    c. 19.5 percent
    d. 22.0 percent

5. To find the proper protective gear to use while inspecting an area where a hazardous chemical is used, you would:

    a. ask an employee that works there.
    b. ask a supervisor.
    c. check the safety equipment guide for the chemicals used.
    d. check the MSDS for chemicals used.

6. Whenever an inspector or sampling technician is in a manhole, how many people should there be above to respond in the event of an emergency?

    a. One
    b. Two
    c. Three
    d. Four

7. Hydrogen sulfide gas smells like:

    a. dead fish.
    b. fuel gas.
    c. rotten cabbage.
    d. rotten eggs.

8. Why are gasoline and volatile solvents objectionable when present in a sewer?

    a. They can produce an explosion hazard.
    b. They tend to cause the solids to vaporize.
    c. They will coagulate floatables and cause stoppages.
    d. They produce noxious odors.

9. When working in the street, signs and cones are needed when:

    a. working in bright sunlight.
    b. over half of the street is blocked.
    c. the speed limit is over 25 MPH.
    d. the street is a state or county highway.

10. How many different areas of traffic control are there?

    a. seven
    b. two
    c. four
    d. five

11. The different areas of traffic control include:

    a. buffer.
    b. bumper.
    c. rest.
    d. lane.

12. When inspecting a plating shop, personal protective equipment would include:

    a. hard hat, steel-toed boots, and splash apron.
    b. splash apron, chemical resistant gloves, and hard hat.
    c. eye goggles or face shield, chemical resistant gloves, and overalls.
    d. chemical resistant gloves, overalls, and hard hat.

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 a wrong answer to any of the diagnostic test questions was chosen, refer to the subsection listed and find the correct reference material to help find the correct answer to the question.

Skill Set 1 Basic Scientific Principles

No.	Answer	Skill Set
1	c	1.2
2	a	1.2
3	c	1.2
4	b	1.1
5	d	1.1
6	a	1.1
7	c	1.2
8	b	1.3
9	c	1.1
10	a	1.1
11	b	1.1
12	c	1.1

Skill Set 2 Sampling and Analysis

No.	Answer	Skill Set
1	c	2.0
2	c	2.0
3	d	2.0
4	b	2.0
5	c	2.0
6	b	2.0
7	b	2.0
8	c	2.0

Skill Set 3 Wastewater and Industrial Processes and Equipment

No.	Answer	Skill Set
1	a	3.1
2	c	3.1
3	c	3.2
4	d	3.2
5	a	3.3
6	d	3.3
7	a	3.4
8	c	3.4
9	d	3.4
10	b	3.5
11	d	3.5
12	b	3.5
13	c	3.5

Skill Set 4 Safety and Traffic Control

No.	Answer	Skill Set
1	b	4.7
2	c	4.6
3	b	4.4
4	c	4.1
5	d	4.5
6	b	4.4
7	d	4.6
8	a	4.1, 4.5
9	b	4.2
10	d	4.2
11	d	4.2
12	c	4.5

Math Solutions

Skill Set 1 Basic Scientific Principles

1. An industry operating an 8-hour shift, 5 days per week, generates 100,000 gallons of wastewater per shift. Their pretreatment system has a capacity of 150 gallons per minute. How long must the pretreatment facility operate to process the wastewater generated each day?

Solution. Known: Wastewater flow in gpd, and treatment capacity in gpm

Unknown: Treatment time/day

The information on operating hours and days is not relevant to the problem. Calculate the time required to treat 100,000 gallons. The multiple-choice answers are in hours. Therefore, convert the time to hours.

$$\text{Flow Rate} = \frac{\text{Volume}}{\text{Time}} \qquad \text{Time} = \frac{\text{Volume}}{\text{Flow Rate}}$$

$$\text{Time} = 100{,}000 \text{ gal} \times \frac{\text{min}}{150 \text{ gal}} \times \frac{\text{hr}}{\text{min}} = 11.1 \text{ hours}$$

2. What is the average detention time, in minutes, for a 40,000 gpd flow going through a 1,500-gallon interceptor?

Solution. Known: Average 24-hour flow, and liquid capacity (volume) of clarifier

Unknown: Average detention or holding time of wastewater in the clarifier

Since hours of discharge are not specified, flow and detention time is averaged over 24 hours. The multiple choice answers are given in minutes. Therefore, convert the average detention time to minutes.

$$40{,}000 \frac{\text{gal}}{\text{day}} \times \frac{\text{day}}{24 \text{ hrs}} \times \frac{\text{hr}}{60 \text{ min}} = 27.8 \text{ gpm}$$

Calculate the average detention time.

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow Rate}}$$

$$\text{Time} = 1{,}500 \text{ gal} \times \frac{\text{min}}{27.8 \text{ gal}}\ 54 \text{ min}$$

3. What total volume of spill containment capacity in gallons is needed for the following tanks if a 12-inch rainfall occurs during a 24-hour period on a common 200-foot by 200-foot spill containment pad? Assume 100 percent containment of all tank capacity is needed

Solution. Known: Dimension of all tanks, dimension of spill pad floor, and depth of rainfall

Unknown: Volume (capacity) of tanks, and volume of rainfall on pad

Use volume formulas from Table 4-1 to calculate volume of each tank.

Tank 1: Vol. = LWH
L, W, and H = 6 ft

Vol. = 6 ft x 6 ft x 6 ft = 216 ft^3

Tank 2: Vol. = LWH

L = 20 ft, W = 4 ft, H = 3 ft

Vol. = 20 ft x 4 ft x 3 ft = 240 ft^3

Tank 3: Vol. = 0.785 D^2H
D = 8 ft, H = 9 ft

Vol. = 0.785 $(8\ ft)^2$ x 9 ft = 452 ft^3

Total Tank Vol. = 216 ft^3 + 240 ft^3 + 452 ft^3
= 908 ft^3

Calculate the rainfall volume. Treat the spill-containment pad like a rectangular tank. Depth of rainfall is the "height" of the tank.

Convert inches to feet:

$$12\ \text{inch} \times \frac{\text{ft}}{\text{inch}} = 1\ \text{ft}$$

Vol. = LWH
L = W = 200 ft, H = 1 ft

Vol = 200 ft x 200 ft x 1 ft = 40,000 ft^3

Sum the tank and rainfall volumes and convert units to gallons.

Total spill-containment capacity =

$$(\text{Tank Vol., ft}^3 + \text{Rainfall Vol., ft}^3)\ 7.48\ \frac{\text{gal}}{\text{ft}^3}$$

$$= (908\ \text{ft}^3 + 40{,}000\ \text{ft}^3)\ 7.48\ \frac{\text{gal}}{\text{ft}^3}$$

$$= 305{,}992\ \text{gal}$$

7. An industry has a wastewater discharge of 10,000 gallons per day containing 5 mg/L of copper. What is the industry's mass emission rate of copper in pounds per day?

Solution. Known: Daily discharge in gpd, concentration of copper in discharge, mg/L

Unknown: Mass discharge (emission) of copper in lb/day

A simple solution for mass emission rate problems is to understand that concentration in mg/L is equivalent to parts per million (ppm) or parts/million parts in dilute solutions. Therefore, 5 mg/L is the same as 5 pounds of copper per million pounds of solution.

Solve the problem converting gallons per day to pounds per day and then multiplying by the concentration.

Mass Emission Rate =

$$\frac{100{,}000\ \text{gal}_{soln}}{\text{day}} \times \frac{8.34\ \text{lb}}{\text{gal}} \times \frac{5\ \text{lb}_{copper}}{1{,}000{,}000\ \text{lbs}_{soln}}$$

$$= 0.42\ \frac{\text{Lb}_{copper}}{\text{day}}$$

Skill Set 2 Sampling and Analysis

1. An industry has five sewer connections with the following discharge rates:

   (1) 300 gpd, (2) 75 gpd, (3) 725 gpd,
   (4) 1,200 gpd, (5) 200 gpd

   A flow-weighted composite sample of 5 liters is desired. How many milliliters of sample from each connection should be composited?

Solution. Known: Flow rate from each connection, and total composite volume

Unknown: Volume of sample from each connection

A flow weighted sample means that the ratio of discrete sample volume to total composite volume is the same as the ratio of each connection discharge rate to the total discharge rate.

Calculate the total discharge rate.

Total Rate = Sum of Individual Rates
= 300 + 75 + 725 + 1,200 + 200 = 2,500 gpd

Total composite sample volume is 5 liters or 5,000 mL. Set up a ratio equation for each connection and solve for the unknown by multiplying both sides by the total sample volume.

$$\frac{(1)}{5{,}000\ \text{mL}} = \frac{300\ \text{gpd}}{2{,}500\ \text{gpd}}$$

$$\cancel{5{,}000\ \text{mL}} \times \frac{(1)}{\cancel{5{,}000\ \text{mL}}} = 5{,}000\ \text{mL} \times \frac{75\ \cancel{\text{gpd}}}{2{,}500\ \cancel{\text{gpd}}}$$

$$(1) = 600\ \text{mL}$$

$$\frac{(2)}{5{,}000\ \text{mL}} = \frac{75\ \text{gpd}}{2{,}500\ \text{gpd}} \qquad (2) = 150\ \text{mL}$$

$$\frac{(3)}{5{,}000\ \text{mL}} = \frac{725\ \text{gpd}}{2{,}500\ \text{gpd}} \qquad (3) = 1450\ \text{mL}$$

$$\frac{(4)}{5{,}000\ \text{mL}} = \frac{1{,}200\ \text{gpd}}{2{,}500\ \text{gpd}} \qquad (4) = 2{,}400\ \text{mL}$$

$$\frac{(5)}{5{,}000\ \text{mL}} = \frac{200\ \text{gpd}}{2{,}500\ \text{gpd}} \qquad (5) = 400\ \text{mL}$$

2. The following results for nickel, in mg/L, were obtained from daily composite samples. Select the correct mean, median, and range of value from the list.

   6.7, 8.6, 9.0, 8.9, 9.0, 8.5, 8.4, 8.7, 6.6, 7.2, 8.5, 9.3, 8.9

Solution. Mean is the average, or the sum of all the values divided by the number of values, in this case, 15 values.

$$\text{Mean} = \frac{\text{Sum of All Values}}{\text{Number of Values}}$$

= 6.7 + 8.6 + 9.0 + 8.9 + 8.9 + 9.0 + 8.5 + 8.4 + 8.7 + 6.6 + 8.8 + 7.2 + 8.5 + 9.3 + 8.9

$$\frac{126}{15} = 8.4$$

The range is simply the difference between the highest value and the lowest value.

Range = $V_H - V_L$ = 9.3 - 6.6 = 2.7

The median is the midpoint of the range of values, where on-half of the values are higher and on-half of the values are lower. Arrange the values from highest to lowest.

9.3, 9.0, 9.0, 8.9, 8.9, 8.9, 8.8, 8.7, 8.6, 8.5, 8.5, 8.4, 7.2, 6.7, 6.6

The midpoint, median value = 8.7.

There are seven values higher than this number and seven values lower. If the total number of values is an even number, the two values closest to the midpoint are averaged to obtain the midpoint, or median value.

References

This section includes the titles and information of primary and secondary references for the Environmental Compliance Inspector. 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

Developing Source Control Programs for Commercial and Industrial Wastewater, WEF Manual of Practice (MOP)
No. OM-4, 1996
ISBN: 1-57278-032-0
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800/666-0206
www.wef.org

Industrial User Inspection and Sampling Manual for POTWs, EPA 831-B-94-001, April 1994
Office of Water (4202)
U.S. Environmental Protection Agency Washington, DC 20460
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
703/605-6000
www.ntis.gov

The following books can be obtained from:

Office of Water Programs
California State University Sacramento
6000 J Street
Sacramento, CA 95819-6025
916/278-6142
www.owp.csus.edu

Pretreatment Facility Inspection: A Field Study Training Program, 3rd Edition, 1996.

Industrial Waste Treatment: A Field Study Training Program, Volume I and II,
2nd Edition, 1995

Treatment of Metal Wastestreams: A Field

study Training Program, *2nd Edition, 1995*

Secondary References

The information contained in the Primary Reference section above provides a solid base of knowledge for the Inspector. Additional references, such as those below, that enhance the material provided in these references may be found at a university library or as indicated for each reference.

Industrial User Permitting Guidance Manual, 1989
Washington, DC: U.S. EPA Office of Wastewater Enforcement and Permits
EPA Water Library
202/267-7786

The following books can be obtained from:

McGraw Hill Book Company
860 Taylor Station Road
Blacklick, OH 43004-0545
800/722-4726

The Nalco Water Handbook
ISBN: 0-07-045872-3

Other basic chemistry textbooks.

Industrial Wastewater Source Control, 1992
ISBN: 0877628556
Technomic Publishing Company, Inc.
851 New Holland Avenue, Box 3535
Lancaster, PA 17604
800/233-9936 or 717/291-5609
www.technomic.com

A Guide to Methods and Standards for the Measurement of Water Flow, by G. Kulin and P. Compton
Published by U.S. Department of Commerce, National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161

Open Channel Flow Measurement Handbook, 5th Edition, 1997 by D. Grant
ISBN: 0-9622757-2-7
Published by ISCO, Inc.
P. O. Box 82531
Lincoln, NE 68501
Available through Amazon.com

Stevens Water Resources Data Book Published by Leopold & Stevens, Inc
P. O. Box 688
Beaverton, OR 97075

Basic Math Concepts for Water and Wastewater Plant Operators
ISBN: 0-87762-808-4
Joanne Kirkpatrick-Price
Technomic Publishing Company, Inc.
851 New Holland Avenue
P. O. Box 3535
Lancaster, PA 17604
800/233-9936 or 717/291-5609
www.technomic.com
Available through Amazon.com

Caltrans Traffic Manual, Chapter 5 Traffic Controls
California Department of Transportation
1900 Royal Oaks Drive
Sacramento, CA 95815
916/445-3520
Available through www.cwea.org/tcp/resourcelinks.htm

The following references can be obtained from:

http://www.cwea.org/tcp/resourcelinks.htm

General Pretreatment Regulations
Title 40, Code of Federal Regulations, Section 403 (40 CFR 403)

Storm Water Discharges, 40 CFR 122.26

The following books can be obtained from:

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

Confined Space Entry, WEF, 1998

Safety and Health in Wastewater Systems, WEF MOP SM-1, 1994
ISBN: 1-881369-87-0

Wastewater Sampling for Process and Quality Control
WEF MOP OM-1, 1996
ISBN: 1-57278-037-1

Appendix A

You and Wastewater Math

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,

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

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

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

$$= 74.8$$

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.

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

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

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.

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

$$= 0.426 \text{ sec}$$

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.

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

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.

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

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) = $(3846.5 \text{ ft}^2)(47 \text{ ft}) = 180{,}785.5 \text{ ft}^3$

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 =

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

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:

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

Rate of flow in gal per minute =

Rate of flow in gallons per minute =

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

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 <u>not</u> 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

Acid: A compound which liberates hydrogen ions, and has a pH below 7.

Alkalinity: The measurement of a sample's capacity to neutralize acid.

Atomic Weight: The sum of the number of protons and the number of neutrons in the nucleus of an atom. Atomic weights of elements are found on periodic tables.

Base: A compound which liberates hydroxide ions, and has a pH above 7.

Biochemical Oxygen Demand (BOD): The quantity of oxygen utilized in the biochemical oxidation of organic matter under standard laboratory procedures for five days at 20° Centigrade, usually expressed as a concentration (e.g., mg/L). BOD measurements are used to indicate the organic "strength" of wastewater.

Biological Treatment: A waste treatment process by which bacteria and other microorganisms break down complex organic or inorganic (e.g., ammonia) materials into simple, nontoxic, more stable compounds.

Categorical Industrial User (CIU): A categorical industrial user is an industrial user (see IU definition below) which is subject to a categorical standard promulgated by the US EPA.

Centrifugal Pumps: Pumps using centrifugal force to convey liquid. Discharge will vary according to inlet and discharge pressure.

Chain-of-Custody: A legal record (which may be a series of records) of each person who had possession of an environmental sample, from the person who collected the sample to the person who analyzed the sample in the laboratory and to the person who witnessed the disposal of the sample.

Chemical Oxygen Demand (COD): Chemical oxygen demand is expressed as the amount of oxygen consumed from the oxidation of a chemical during a specific test (in mg/L). As such, COD is a measure of the oxygen-consuming capacity of the organic matter present in the wastewater. The results of the COD test are not necessarily related to the BOD because the chemical oxidant responsible for utilizing the oxygen may react with substances, which bacteria do not stabilize.

Cipolletti Weir: A trapezoidal sharp-crested weir for measurement of liquid discharge in open channels.

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 US EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to publicly owned treatment works (POTWs).

Composite Sampling: A collection of individual samples obtained at regular intervals, based either on flow or time. The individual samples are combined proportionally.

Concentration Based Discharge Limits: Allowable concentration of a pollutant in wastewater discharges, usually expressed as a concentration in the discharge (i.e., mg/L).

Confined-Space: A space which, by design, has limited openings for entry and exit, unfavorable natural ventilation which could contain or produce dangerous air contaminants (or create an atmosphere of oxygen deprivation), and which is not intended for continuous employee occupation. A permit may be required under OSHA to enter a confined space.

Density: The relationship between weight and volume, e.g., grams per cubic centimeter, or pounds per gallon.

Detention Times: The residence time of wastewater undergoing treatment in a treatment unit such as a clarifier or tank. Minimum detention times are required for settling, chemical treatment and biological treatment.

Doppler Flow Meter: An ultrasonic flowmeter that measures the velocity of liquid in a pipe flowing full.

Electroplating: The process for applying a thin metal coating to the surface of a metal (substrate) by electrodeposition of dissolved metal in a plating solution.

Flow Equalization: Temporary storage of wastewater flow to provide more uniform flow or waste characteristics for treatment or discharge.

Grab Sampling: A sample which is taken from a wastestream without regard to the flow in the wastestream and over a period of time not to exceed 15 minutes.

Holding Time: The maximum time allowed between when a sample is taken and when it must be analyzed in the laboratory in accordance with standard preservation, storage and analytical procedures.

Hydrogen Sulfide (H_2S): Dissolved Sulfide is produced by the biological reduction of sulfate and organic matter under anaerobic (oxygen–free) conditions. Dissolved sulfide can combine with hydrogen to form hydrogen sulfide gas. H_2S gas is potentially hazardous to sewer maintenance workers.

Industrial User (IU): Any non-domestic source which introduces pollutants into a POTW.

Industrial Wastewater: Any non-domestic wastewater (excluding storm water).

Magnetic Flowmeter: A flowmeter that creates a magnetic field across a pipe flowing full, in which the liquid acts as a conductor, to measure the velocity and flow in the pipe.

Mass Based Limits: Discharge limits based on allowable dry weight of pollutant, usually expressed in pounds per day (lb/day).

Mass Emission Rate: The rate of discharge of the dry weight of a pollutant in wastewater or air, expressed in lb/day or kilogram per day (kg/day).

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

Molarity: Moles per liter, a measure of concentration.

Molecular Weight: The sum of the atomic weights of all atoms making up a molecule.

National Pollutant Discharge Elimination System (NPDES): Federal permitting program for discharging effluent to surface water, required under CWA.

National Prohibited Discharges: Prohibitions applicable to all nondomestic dischargers regarding the introduction of pollutants into POTWs set forth at 40 CFR 403.5.

Neutralization: Addition of an acid or alkali (base) to a liquid to cause the pH of the liquid to move toward a neutral pH of 7.0.

Normality: Equivalents per liter. A measure of concentration.

Oxidation-Reduction: Reactions involving the transfer of electrons, with oxidation being loss of electrons and reduction being the gain in electrons. ORP, or oxidation-reduction potential, is the qualitative measure of the state of oxidation in metal waste treatment systems. ORP is used to control the chemical addition to optimize the oxidation of co pounds such as cyanide or reduction of metals such as hexavalent chromium. ORP, or oxidation-reduction potential, is the qualitative measure of the state of oxidation in metal waste treatment systems. ORP is used to control the chemical addition to optimize the oxidation of compounds such as cyanide or reduction of metals such as hexavalent chromium.

Parshall Flume: An open channel flow measuring device with a constricted throat which produces a head, or water depth that is related to discharge.

Pass-Through: The passage of untreated pollutants through a POTW which could violate applicable water quality standards or NPDES effluent limitations.

pH: The hydrogen ion (H+) concentration. The measure of the relative acidity or alkalinity of a solution on a scale from 0 (acidic) to 14 (basic).

Pollutants of Concern (POC): Compounds in wastewater that pose a potential threat to the POTW or its ability to comply with environmental standards.

Positive Displacement Pumps: Pumps that use piston, diaphragm action, etc., to convey liquid. Discharge rate does not vary with inlet or outlet pressure.

Pretreatment Standard: Any regulation promulgated by the EPA in accordance with Section 307(b) and (c) of the Clean Water Act which applies to a specific category of industrial users and provides limitations on the introduction of pollutants into POTWs. This term includes the prohibited discharge standards under 40 CFR 403.5, including local limits [40 CFR 403.3 (j)].

Precipitation: Part of a treatment process that takes dissolved pollutants out of solution to form a precipitate that can be removed by filtration or settling.

Printed Circuit Board: A circuit for electronic apparatus made by depositing conductive material, usually copper, on an insulating surface.

Process-Inhibition: The concentration of a pollutant that will interfere with a biological treatment process in the POTW.

Publicly Owned Treatment Works (POTW): A treatment works which is owned by a state, municipality, city, town, special sewer district or other publicly owned and financed entity as opposed to a privately (industrial) owned treatment facility. This definition includes any devices and systems used in the storage, treatment, recycling and reclamation of municipal sewage or industrial wastes of liquid nature. It also includes sewers, pipes and other conveyances only if they convey wastewater to a POTW treatment plant. The term also means the municipality (public entity) which has jurisdiction over the indirect discharges to and the discharges from such a treatment works.

Settling: Treatment process by which settleable or floatable solids are removed from wastewater by gravity separation in a tank or other vessel.

Sludge Quality Standard: Allowable concentration or mass of a pollutant in POTW sludge, or biosolids, used for land application.

Specific Gravity: (1) Weight of a particle, substance, or chemical solution in relation to the weight of an equal volume of water. Water has a specific gravity of 1.000 at 4°C (39°F). (2) Weight of a particular gas in relation to an equal volume of air at the same temperature and pressure (air has a specific gravity of 1.0). Chlorine has a specific gravity of 2.5 as a gas.

Total Suspended Solids (TSS): Residue that is removed from a wastewater sample by a standard laboratory filtration procedure, expressed as mg/L.

Turbine Meter: A positive displacement meter with an internal turbine turned by the water flow. Flow is proportional to turbine rotation speed.

V-notch Weir: A triangular sharp-crested weir for measurement of liquid discharge in open channels.

Worker Right-to-Know Laws: Employee “Right-to-Know” legislation requires employers to inform employees (treatment plant operators) of the possible health effects resulting from contact with hazardous substances. At locations where this legislation is in force, employers must provide employees with information regarding any hazardous substances which they might be exposed to under normal working conditions or reasonably foreseeable emergency conditions resulting from workplace conditions. OSHA’s “Hazard Communication Standard (HCS)” (Title 29 CFR Part 1910.1200) is the federal regulation and state statutes are called “Right-to-Know Laws.”

40 CFR 121-124: These are the Federal storm water regulations for the permitting of municipalities and industries. Regulations define storm water terms, permitting, inspecting, and sampling requirements.

40 CFR 136: These are the regulations for sampling preservation, and analyses of water, wastewater, and solid waste.

40 CFR 403: These are the Federal regulations defining the elements of a pretreatment program, prohibited discharges, and approval process for establishing a pretreatment program.

Appendix C

Common Acronyms and Abbreviations

AA	atomic absorption
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
AS	activated sludge
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWT	advanced wastewater treatment
AWWA	American Water Works Association
BECP	Business Emergency and Contingency Plan
BNR	biological nutrient removal
BOD5	biochemical oxygen demand after 5 days
BTU	British thermal unit
C	Celsius
Cal OSHA	California Occupational Safety and Health Act
CalEPA	California Environmental Protection Administration
CBOD	carbonaceous biochemical oxygen demand
CCE	carbon chloroform extract
CCR	California Code of Regulations
cf	cubic feet (foot)
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH4	Methane
CIU	Categorical Industrial User
CM	common mode
CMOM	Capacity Management, Operations, and Maintenance
COD	chemical oxygen demand
CPU	central processing
CRWA	California Rural Water Association
CSP	confined-space permit
CT	current transformer
CWA	Clean Water Act
CWEA	California Water Environment Association
DAF	dissolved air flotation
DO	dissolved oxygen
DOHS	California Department of Health Services
DV/DT	($\Delta V/\Delta T$) 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
F/M	food to microorganism ratio
ft	feet (foot)
ft^2	square foot
ft^3	cubic feet

FTU	formazin turbidity unit
GAC	granular activated carbon
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
HPLC	high-performance liquid chromatography
Hz	Hertz
IC	ion chromatograph
ICP	inductively coupled plasma
IEEE	Institute of Electrical and Electronics Engineers
IIPP	Injury and Illness Prevention Plan
IML	Interface Management Language
JTU	Jackson Turbidity Unit
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
M	mole or molar
MA	millamps
MBAS	methylene blue active substance
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCRT	mean cell residence time
MDL	method detection limit
MG	million gallons
mg	milligram
mg/L	milligrams per liter
mgd	million gallons per day
min	minute
MIS	Manufacturing Information System
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MMI	Man Machine Interface
MOP	Manual of Practice
MPN	most probably number
MS	mass spectrometer
MSDS	Material Safety Data Sheets
N	normal
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NM	Normal Mode
NOCA	National Organization for Competency Assurance
NOD	nitrogenous oxygen demand
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
OTE	oxygen transfer efficiency
P	Pico, a metric prefix meaning one millionth of a millionth, or one trillionth (10^{-12})

PC	personal computer
PCB	polychlorinated biphenyls
pH	potential of hydrogen
PI&D	piping and instrumentation diagram
PID	proportional gain, integral action time and derivative action time
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
PSIA	pounds per square inch absolute
PSID	pounds per square inch differential
PSIG	pounds per square inch gage
PVC	polyvinyl chloride (pipe)
QA/QC	quality assurance/quality control
RAS	return activated sludge
RBC	rotating biological contactor
RCP	reinforced concrete pipe
RFI	Radio Frequency Interference
RMS	root mean square
RTD	resistance temperature device
RWQCB	Regional Water Quality Control Board (State of California)
SCADA	supervisory control and data acquisition
SCR	semiconductor, or silicon controlled rectifier
SD	standard deviation
SDI	sludge volume index
sec	second
SI	System Internationale D'Unites (metric units)
SS	suspended solids
SSO	sanitary sewer overflow
SVI	sludge volume index
SVR	sludge volume ratio
SWRCB	(California) State Water Resources Control Board
TAC	Technical Advisory Committee
TC	total carbon
TCP	Technical Certification Program
TDS	total dissolved solids
TF	trickling filter
THD	total harmonic distortion
TIC	total inorganic carbon
TMDL	total maximum daily load
TOC	total organic carbon
TOD	total oxygen demand
TS	total solids
TSS	total suspended solids
TU	turbidity unit
U	micro, a metric prefix meaning one millionth
UPS	uninterruptible power supply
USB	universal serial bus
USEPA	United States Environmental Protection Agency
V	volt
VAC	volts of alternating current
VCP	vitrified clay pipe
VFD	variable frequency drive
VOC	volatile organic chemicals
VOM	volt Ohm meter
VSR	volatile solids reduction
VSS	volatile suspended solids
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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