Before paying for your examination registration, be sure you understand the contents of this bulletin. Please retain and use it as a reference when contacting PSI.

PSI
3210 E Tropicana
Las Vegas, NV 89121
www.psiexams.com

COMMONWEALTH OF VIRGINIA DEPARTMENT OF PROFESSIONAL AND OCCUPATIONAL REGULATION

WASTEWATER WORKS OPERATOR CLASSES 1-4 EXAMINATION CANDIDATE INFORMATION BULLETIN

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EXAMINATIONS BY PSI

This Candidate Information Bulletin provides you with information about the examination and application process for becoming licensed as a Wastewater Works Operator in the Commonwealth of Virginia. To be licensed, you must pass an examination to confirm that you have attained at least a minimum level of knowledge regarding the principles, practices, statutes and regulations. The Department of Professional and Occupational Regulation (DPOR) has contracted with PSI to conduct its examination program. PSI provides examinations through a network of computer examination centers in Virginia. PSI works closely with DPOR and its Examination Review Committee to be certain that examinations meet local, national and international requirements in basic principles and examination development standards.

This Candidate Information Bulletin provides you with information on how to acquire licenses for the following.

Wastewater Works Operator Classes 1, 2, 3, 4

Questions regarding applications for licensure should be directed to the:

Commonwealth of Virginia
Department of Professional and Occupational Regulation
Board for Waterworks and Wastewater Works Operators and Onsite Sewage System Professionals
9960 Mayland Drive, Suite 400
Richmond, VA 23233
(804) 367-8595
www.dpor.virginia.gov

email: waterwasteoper@dpor.virginia.gov

All questions regarding the scheduling of your examination should be directed to:

PSI
3210 E Tropicana
Las Vegas, NV 89121

(800) 733-9267 • Fax (702) 932-2666 • www.psiexams.com

EXAMINATION ELIGIBILITY AND APPROVAL PROCESS

In order for a candidate to become eligible to take an examination, you must submit a Virginia Wastewater Works Operator application to DPOR.

APPLICATION FORM. *This application can be found online at www.dpor.virginia.gov, or you may send an email request to waterwasteoper@dpor.virginia.gov or by calling (804) 367-8595.*

Upon approval of eligibility, you will be mailed a confirmation notice containing instructions for scheduling an appointment to take the examination. If you are determined to be ineligible, DPOR will notify you.

New candidates have one year from the Application approval date to pass the examination or they must reapply and meet all current requirements.

EXAMINATION STUDY MATERIALS

The following is a list of possible study materials for the Wastewater Works Operator examinations. The list is given to identify resources and does not constitute an endorsement by PSI or by DPOR.

NOTE: All examinations are open-book. You must bring your own references as they are not provided at the test site. You may use any reference materials related to the content outlines. You may use later editions of references as they become available, however, all code examination questions will be based on the edition of the code book that is listed.

Candidates may bring any references into the examination room, textbooks and training manuals, which are related to the profession and formulas included as part of a textbook or training manual. Formulas are also provided with the examination booklets. Candidates may highlight and tab textbooks and training manuals prior to entering the exam room.

Study guides that primarily provide test questions are not permitted. Sample examinations are not permitted.

The URL listed for each reference is generated from the most current searches. However placement of material on websites may be modified resulting in some discrepancies. If you are unable to find the reference under the URL listed, it is recommended that you search online via a search engine (i.e., Google).

The Code of Federal Regulations, Title 40, Part 136 - Sampling and Testing Guidelines, takes precedence over all other references for items related to compliance sampling and testing.

- Standard Methods for Examination of Water and Wastewater, 22nd, Lenore S. Clescerl, American Water Works Association, 6666 W Quincy Avenue, Denver, CO 80235, (800) 926-7335, http://www.awwa.org/store/productdetail.aspx?productid=28493774
- Manual of Practice #11: Operation of Municipal Wastewater Treatment Plants, 6th Edition, Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314-1994, (800) 666-0206, http://accessengineeringlibrary.com/browse/operation-of-municipal-wastewater-treatment-plants-mop-no-11-sixth-edition
- Advanced Waste Treatment, 2002, Office of Water Programs, California State University, Sacramento Foundation, 6000 J Street, Sacramento, CA 95819-6025, (916) 278-6142, http://www.amazon.com/Advanced-Waste-Treatment-Kenneth-Kerri/dp/188470140X
- Activated Sludge - Manual of Practice No. OM-9, 2nd Edition, 2002, Activated Sludge Task Force, Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314-1994, (800) 666-0206, http://www.e-wef.org/OnlineStore/ProductDetail/tabid/55/ProductId/3

693/Subsystem/INV/ProductCode/MM2023/Default.aspx

- Basic Wastewater Licensure Review Volumes 1 and 2, 5th Edition, Office of Operator Training, Virginia Department of Environmental Quality, 629 East Main Street, Richmond, VA 23219, (804) 698-4000, http://www.deq.virginia.gov/Portals/0/DEQ/Water/WastewaterTreatment/Manual%20Price%20List%207%201%2013.pdf
- Advanced Wastewater Licensure Review, 5th Edition, Office of Operator Training, Virginia Department of Environmental Quality, 629 East Main Street, Richmond, VA 23219, (804) 698-4000, http://www.deq.virginia.gov/Portals/0/DEQ/Water/WastewaterTreatment/Manual%20Price%20List%207%201%2013.pdf
- Virginia Adminstrative Code Title 9, Agency 25, Chapter 31, Section 10 - Virginia Permit Regulations, 2012, http://register.dls.virginia.gov/details.aspx?id=3081
- Code of Federal Regulations, Title 40, Part 136 - Sampling and Testing Guidelines, (866) 512-1800 http://www.epa.gov/region9/qa/pdfs/40cfr136_03.pdf
- Code of Federal Regulations Title 40, Chapter 503 – Biosolids, (866) 512-1800 http://yosemite.epa.gov/r10/water.nsf/NPDES%2BPermits/Sewage%2BS825/$FILE/503-032007.pdf
- Code of Federal Regulations – 29, Parts 1900 to 1910.999 - Revised as of July 1, 2004, (866) 512-1800 https://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=standards&p_toc_level=0
- Manage for Success - Effective Utility Leadership Practices, 1st Edition, 2005, Office of Water Programs, California State University, Sacramento Foundation, 6000 J Street, Sacramento, CA 95819-6025, (916) 278-6142, http://www.owp.csus.edu/courses/management/manage-for-success-effective-utility-leadership-practices.php
- Manual on the Causes and Control of Activated Sludge Bulking, Foaming, and Other Solids Separation Problems, 3rd Edition, David Jenkins, Michael G. Richard, Glen T. Daigger, CRC Press, 2000 NW Corporate Blvd., Boca Raton, FL 33431, (800) 272-7737, http://www.crcpress.com/product/isbn/9781566706476
- Prime Movers: Engines, Motors, Turbines, Pumps, Blowers, and Generators. Manual of Practice OM, 1984, Water Environment Foundation, 601 Wythe Street Alexandria, VA 22314-1994 (800) 666-0206 http://www.amazon.com/Prime-Movers-Generators-Pollution-Federation/dp/0943244560
- Operation of Wastewater Treatment Plants: A Field Study Training Program, Volume II, 7th Edition, 2007, Office of Water Programs, California State University, Sacramento Foundation, 6000 J Street, Sacramento, CA 95819-6025, (916) 278-6142, http://www.owp.csus.edu/courses/wastewater/operation-of-wastewater-treatment-plants-vol-ii.php
- Operation of Wastewater Treatment Plants: A Field Study Training Program, Volume I, 7th Edition, 2008, Office of Water Programs, California State University, Sacramento Foundation, 6000 J Street, Sacramento, CA 95819-6025, (916) 278-6142, http://www.owp.csus.edu/courses/wastewater/operation-of-wastewater-treatment-plants-vol-i.php
- *VA Occupational Safety and Health Program* (VOSH) – (Chapters 16 VAC 25-60-10, 16 VAC 25-140-10, 16 VAC 25-150-10, 16 VAC 25-160-10, and 16 VAC 25-170-10, excerpts included) the Virginia modifications to the Federal OSHA rules. Virginia Occupational Safety and Health Enforcement, Department of Labor and Industry, 10515 Battleview Parkway, Manassas, VA 20109, (703) 392-0900, http://www.doli.virginia.gov/vosh_enforcement/vaunique_standards.html

Candidates may not bring handwritten notes, legal pads or notepads of any kind, and loose papers into the examination room. Handwritten notes inserted into training manuals must be removed prior to entering the examination room or they will be confiscated by the proctor. Handouts provided by the trainers and made part of the training manual are allowed.

If candidates have written notes covering the inside covers and/or any blank pages in the reference books or manuals, they must be erased, scratched through or covered prior to entering the examination room or those references will be confiscated by the proctor. If there are notes written in the margins of reference books and training manuals, they will be allowed in the examination room. It is difficult for proctors to tell whether candidates are copying questions and answers or bringing in previously written questions and answers into the exam. To have proctors examine every page of a reference or note would delay the exam administration and create a burden on both candidates and proctors. For this reason, we expect candidates to refrain from bringing in any handwritten notes on separate papers and limiting the notes in reference materials, as described above.

The following list of tabs may be used. These items may be purchased at local office supply stores.

Acceptable Tabs
Avery Swift Tabs Self-Adhesive Permanent Plastic Tabs
Redi-Tag Self-Stick Permanent Adhesive Index Tabs
Unacceptable Tabs
Post-It Index Flags
Post-It Flags

EXAMINATION CONTENT OUTLINE

If a test question answer could differ because of conflicting information in test reference sources, a legal requirement such as a code, law or regulation overrides any other reference. If two legal requirements appear to conflict, the state-specific code, law or regulation overrides the national one. Information from sources on the test reference list overrides information from other sources or persons.

The Examination Content Outline has been approved by the Virginia Board for Waterworks and Wastewater Works Operators and Onsite Sewage System Professionals (Board). This outline reflects the minimum knowledge required by a Wastewater Works Operator to perform their duties to the public in a competent and responsible manner. Changes in the examination content will be preceded by changes in the published examination content outline.

Use the outline as the basis of your study. The outline lists the topics that are on the examination and the number of items for each topic. Do not schedule your examination until you are familiar with all topics in the outline. The examination is 4 hours in length.

	Exam Class			
Topic Information	Class 1	Class 2	Class 3	Class 4
Evaluate Incoming Wastestream/Sidestream Characteristics	2	3	3	3
Monitor, Evaluate and Adjust Treatment Processes	27	26	23	19
Evaluate and Maintain Equipment	7	6	8	10
Operate Equipment	8	7	6	7
Collect Samples and Interpret Analyses	10	9	6	7
Perform Laboratory Analyses	9	9	6	7
Perform Security, Safety and Administrative Procedures	12	10	8	7
Total Number of Items	**75**	**70**	**60**	**60**

In order to pass the examination, you must achieve the minimum score listed below.

Exam Class	# of Items	Minimum Score Required to Pass
Class 1	75	52
Class 2	70	49
Class 3	60	40
Class 4	60	39

SCHEDULING PROCEDURES

EXAMINATION FEE

Examination Fee $80

NOTE: EXAMINATION FEES ARE NOT REFUNDABLE OR TRANSFERABLE. THE EXAMINATION FEE IS VALID FOR ONE YEAR FROM THE DATE OF PAYMENT

INTERNET REGISTRATION

For the fastest and most convenient test scheduling process, PSI recommends that candidates register for their exams using the Internet. Candidates register online by accessing PSI's registration website at www.psiexams.com. Internet registration is available 24 hours a day.

- Log onto PSI's website and create an account. Please enter your email address and first and last name. This information must match exactly with the information PSI has on file. Be sure to **check the box next to** "*Check here to attempt to locate existing records for you in the system*"
- You will be asked to select the examination and enter your ID# (the same ID# that you used in filling out the application with DPOR). Your record will be found and you will now be ready to pay and schedule for the exam. Enter your zip code and a list of the testing sites closest to the zip code you entered will appear. Once you select the desired test site, available dates will appear. If you have problems contact PSI at (855) 229-9302 for help.

TELEPHONE

The second fastest method of scheduling is via the telephone with PSI's Interactive Voice Response system (IVR) during non-business hours or through live registrars during business hours. For telephone registration, you will need a valid VISA or MasterCard. Call (855) 229-9302, 24 hours a day and register using the Automated Registration System. Otherwise, PSI registrars are available Monday through Friday, between 7:30 am and 8:00 pm and Saturday, between 11:00 am and 5:00 pm, Eastern Time.

CANCELING AN EXAMINATION APPOINTMENT

You may cancel and reschedule an examination appointment without forfeiting your fee if your *cancellation notice is received 2 calendar days before the scheduled examination date*. For example, for a Monday appointment, the cancellation notice would need to be received on the previous Saturday. You may call PSI at (855) 229-9302. Please note that you may also use the automated system, using a touch-tone phone, 24 hours a day in order to cancel and reschedule your appointment.

Note: A voice mail message is not an acceptable form of cancellation. Please use the PSI Website, automated telephone system (IVR), or call PSI and speak to a Customer Service Representative.

SCHEDULING A RE-EXAMINATION

It is not possible to make a new examination appointment on the same day you have taken an examination; this is due to processing and reporting scores. A candidate who tests unsuccessfully on a Wednesday can call the next day, Thursday, and retest as soon as Friday, depending upon space availability. In order to retest, you must follow the steps for scheduling as outlined earlier.

MISSED APPOINTMENT OR LATE CANCELLATION

Your registration will be invalid, you will not be able to take the examination as scheduled, and you will forfeit your examination fee, if you:

- Do not cancel your appointment 2 calendar days before the schedule examination date;
- Do not appear for your examination appointment;
- Arrive after examination start time;
- Do not present two forms of valid ID, with one bearing your photograph.

SPECIAL EXAMINATION ARRANGEMENTS

All examination centers are equipped to provide access in accordance with the Americans with Disabilities Act (ADA) of 1990, and every reasonable accommodation will be made in meeting a candidate's needs. Applicants with disabilities must fill out the form at the end of this Candidate Information Bulletin and fax to PSI (702) 932-2666.

EXAMINATION SITE CLOSING FOR AN EMERGENCY

In the event that severe weather or another emergency forces the closure of an examination site on a scheduled examination date, your examination will be rescheduled. PSI personnel will attempt to contact you in this situation. However, you may check the status of your examination schedule by calling (800) 733-9267. Every effort will be made to reschedule your examination at a convenient time as soon as possible. You will not be penalized. You will be rescheduled at no additional charge.

WALK-IN EXAMINATIONS

YOU MUST PRESENT A CONFIRMATION NOTICE OR A FAILING SCORE REPORT TO BE ELIGIBLE FOR A WALK-IN EXAMINATION. You are strongly encouraged to schedule an examination. However, you may take the examination as a walk-in candidate. Walk-in examinations are available on a space-available, "first-come", "first-served" basis. Walk-in candidates will only be admitted after all scheduled candidates have been admitted. Because of seating limitations at examination centers, admission cannot be guaranteed to walk-in candidates. There is an additional fee of $15 for walk-in candidates. This fee must be paid by money order, cashier's check, or company check at the examination center.

COMPUTER EXAMINATION CENTER LOCATIONS

FALLS CHURCH LEESBURG PIKE
MCILVAINE BUILDING
6201 Leesburg Pike, Suite 404
Falls Church, VA 22044
From I-495, take new exit 47 (old exit 10) (Leesburg Pike) and proceed east past Little Falls. Leesburg becomes Broad St. Proceed on Broad St thru Falls Church. Broad St turns back into Leesburg Pike (Rte 7 East). Follow Rte 7-East signs through the Seven Corners Intersection. Building is on the corner of Leesburg Pike and Patrick Henry Drive. Turn right onto Patrick Henry Dr and right into the building parking lot, then left on the up ramp to the main parking lot. Parking and entrance to the back of the building.

TYSONS CORNER AREA
1651 Old Meadow Rd, Suite B01
McLean, VA 22102
From the Beltway take the McLean Exit (Route 123 North). Turn right on Old Meadow Road (the first traffic light). The site is the first building on the left. Use the back entrance. Visitor parking for Tysons Corner is in the front of the building (closest to Old Meadow Road).

RICHMOND
Moorefield VI Building
620 Moorefield Park Drive
Suite 205
Richmond, VA 23236
From I-64E, take the Parham Rd exit and turn right. N Parham Rd/VA-73 S becomes VA-150 S/Chippenham Pkwy. Merge onto VA-76 S/Powhite Pkwy. Merge onto Midlothian Turnpike West. Turn left on Moorefield Park Dr.

PSI VIRGINIA BEACH
Pembroke IV Building
291 Independence Blvd, Suite 140
Virginia Beach, VA 23462
From I-264 merge onto Independence Blvd/VA-225 via Exit 17B. Proceed across Va Beach Blvd and make a left turn onto Broad Street (across from Sears). The site is located within the Pembroke Four office building.

PSI CHARLOTTESVILLE
2114 Angus Road, Suite #105-B
Charlottesville, VA 22901
If going West on US-250, turn right onto US-29N/N Emmet St. Continue on Emmet Street and turn left on Angus Rd.
If going East on US-250, turn left onto US-29N/N Emmet St. Continue on Emmet Street and turn left on Angus Rd.

ROANOKE AREA
Fralin and Waldron Office Park
2847 Penn Forest Blvd
Building D, Suite 200
Roanoke, Virginia 24018
From 81 - take 220 Exit (Downtown Roanoke). From 220 take the Franklin Road Exit (not the Franklin Bus Exit). At the stop light make a right. Franklin Road will turn into Electric Road. Keep going straight until you come to Chaparral Dr and go left. You will see the Fralin & Waldron Bldg to your left. At the next stop light go left.
If you are traveling from 220 take the first exit, Franklin Road. Follow directions above.

EASTERN SHORE AREA
Beaglin Park Plaza
1323 Mt. Hermon Rd., Suite 2A
Salisbury, MD 21801
The complex is south of Route 50 and west of the 13 By-pass. From Route 50, turn south on Beaglin Park Drive. Turn left at the first light, Mt Hermon Rd. Turn left into Beaglin Park Plaza.

SOUTHWESTERN AREA
Johnson City
904 Sunset Drive, Ste 7A
Johnson City, TN 37604
Take I-26 to Exit 19 (Old number 36). Go South on Highway 381 (North State of Franklin Road) approximately 2.2 miles. At the 4th light turn left (this is Sunset Drive), go approximately .7 tenths of a mile. There is a large building on the left hand side of the road. This is 904 Sunset Drive. Suite 7A is in the row of office spaces behind this building.

REPORTING TO THE EXAMINATION CENTER

On the day of the examination, you should arrive at least 30 minutes before your appointment. This extra time is for sign-in and identification and familiarizing you with the examination process. **If you arrive late, you may not be admitted to the examination center and you will forfeit your registration fee.**

REQUIRED IDENTIFICATION

You must provide 2 forms of VALID (not expired) identification. One must be a government-issued identification (Driver's License, State ID, Passport) which bears your signature, has your photograph, or a complete physical description. The second ID must have your signature and preprinted legal name. All identification provided must match the name on the registration form. If you cannot provide the required identification, you must call (800) 733-9267 1 month prior to your scheduled appointment to arrange a way to meet this security requirement. ***Failure to provide all of the required identification at the time of the examination without notifying PSI is considered a missed appointment and you will not be able to take the examination at that time.***

NOTE: If you recently changed your name, or if your last name includes a generation indicator (e.g., Jr., III), be sure that your name is the same on your education verification, your examination registration form, and your 2 forms of identification.

SECURITY PROCEDURES

The following items are **not** permitted in the examination room:

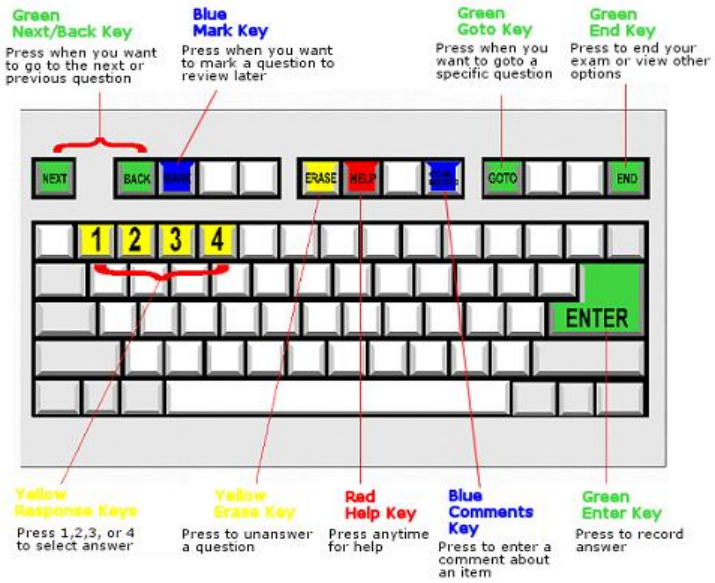
- All personal electronic devices except those that are a medical necessity.
- Children, guests, cellular telephones, personal digital assistants (PDAs), recording devices, cameras, pagers, purses, notebooks, notebook computers, reference or reading material, music players, radios, electronic games, or briefcases.
- Personal items including watches, backpacks, pens, pencils, or other writing devices, food, drinks (unless prior approval is obtained by your regulatory entity) and good-luck items.
- Hats, baseball caps, or visors (with the exception of religious apparel), coats, shawls, hooded clothing, heavy jackets or overcoats.

The following security procedures will apply during the examination:

- Candidates may bring reference books and training manuals. Reference books may be highlighted, underlined, and/or indexed. Notes previously written in the margins are acceptable. Sample examinations are not allowed.
- Candidates may not bring in handwritten notes, legal pads or notepads of any kind. No loose papers are allowed. Handwritten notes inserted into training manuals must be removed.
- NO conversing or any other form of communication among candidates is permitted once you enter the examination area.
- Only non-programmable calculators that are silent, battery-operated, do not have paper tape printing capabilities, and do not have a keyboard containing the alphabet will be allowed in the examination site.
- No smoking, eating, or drinking will be allowed at the examination site.
- You may not exit the building during the examination.
- Copying or communicating examination content is a violation of PSI security policy and the State Law. Either one may result in the disqualification of examination results and may lead to legal action.

TAKING THE EXAMINATION BY COMPUTER

Taking the PSI examination by computer is simple. You do not need any computer experience or typing skill. You will use fewer keys than you use on a touch-tone telephone. All response keys are colored and have prominent characters. An illustration of the special keyboard is shown here. You may also use the mouse.



IDENTIFICATION SCREEN

You will be directed to a semiprivate testing station to take the examination. When you are seated at the testing station, you will be prompted to confirm your name, identification number, and the examination for which you are registered.

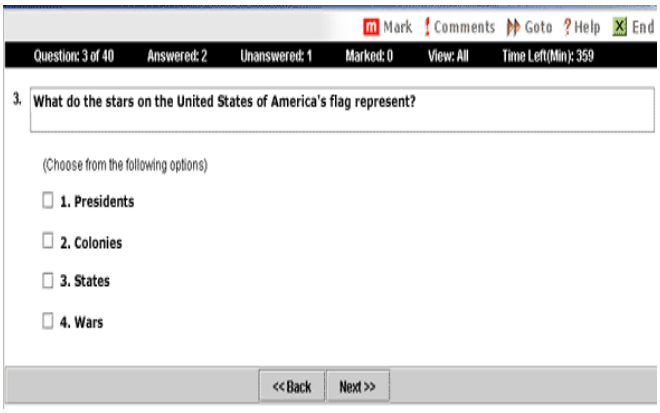
TUTORIAL

Before you start your examination, an introductory tutorial to the computer and keyboard is provided on screen. The time you spend on this tutorial (up to 15 minutes) does NOT count as part of your examination time. Sample questions are included as part of the tutorial so that you may practice using the keys, answering questions, and reviewing your answers.

One question appears on the screen at a time. During the examination, minutes remaining will be displayed at the top of the screen and updated as you record your answers.

EXAMINATION

A sample question display follows. During the examination, you would press 1, 2, 3, or 4 to select your answer or press "MARK" to mark it for later review. You would then press ENTER to record your answer and move on to the next question.



IMPORTANT: After you have entered your responses, you will later be able to return to any question(s) and change your response, provided the examination time has not run out.

EXPERIMENTAL ITEMS

In addition to the number of examination items specified in the "Examination Content Outlines", a small number (5 to 10) of "experimental" questions may be administered to candidates during the examinations. These questions will not be scored and the time taken to answer them will not count against examination time. The administration of such unscored, experimental questions is an essential step in developing future licensing examinations.

EXAMINATION REVIEW

PSI, in cooperation with DPOR, will be consistently evaluating the examinations being administered to ensure that the examinations accurately measure competency in the required knowledge areas Comments may be entered on the computer keyboard during the examination. Your comments regarding the questions and the examinations are welcomed. Comments will be analyzed by PSI examination development staff. While PSI does not respond to individuals regarding these comments, all substantive comments are reviewed. If an error affecting examination scores is discovered as a result, which occurs very rarely, the examination scores of all affected candidates will be automatically adjusted. **This is the only review of the examination available to candidates.**

SCORE REPORTING

Your score will be given to you immediately following completion of the examination. The following summary describes the score reporting process:

- On screen – your score will appear immediately on the computer screen. This will happen automatically at the end of the time allowed for the examination; if you are using review features, you will be able to obtain your score immediately when you indicate that you have finished and would like to see your results.
  - If you pass, you will immediately receive a successful notification.
  - If you do not pass, you will immediately receive an unsuccessful notification on the screen along with a diagnostic report indicating your strengths and weaknesses by examination type. Registration forms for submittal to PSI to retake the examination will be available at the examination site.
- On paper – an official score report will be printed at the examination site.

DUPLICATE SCORE REPORTS

You can write to PSI to request a duplicate of your score report for up to 1 year after your examination. The fee for a duplicate score report is $15. *Money Order or cashier's check ONLY.*

LICENSE APPLICATION INSTRUCTIONS

After completing the examination, PSI shall transmit scores automatically to the Board at DPOR. Applicants who successfully pass the examination will receive their license in the mail from DPOR, with no additional action typically required on the part of the applicant. Applicants who fail to pass the exam may choose to re-take the exam by re-scheduling with PSI and submitting a new exam fee to PSI.

Questions regarding applications for licensure or how to obtain a Wastewater Works Operator license should be directed to the:

Commonwealth of Virginia
Department of Professional and Occupational Regulation
Board for Waterworks and Wastewater Works Operators and Onsite Sewage System Professionals
PO Box 26792
Richmond, VA 23261
(804) 367-8595
www.dpor.virginia.gov

Virginia Need-to-Know Criteria for Wastewater Works Operator

Core Competencies for Wastewater Works Operator

Evaluate Incoming Wastestream/Sidestream Characteristics	Class 4	Class 3	Class 2	Class 1
Biological/Chemical	X	X	X	X
Color	X	X	X	X
Flow pattern	X	X	X	X
Mixing pattern	X	X	X	X
Odor	X	X	X	X
Solids concentration	X	X	X	X
Volume	X	X	X	X

Required Capabilities:

- Ability to communicate observations verbally and in writing
- Ability to discriminate between normal and abnormal conditions
- Knowledge of normal characteristics of wastewater

Monitor, Evaluate and Adjust Treatment Processes	Class 4	Class 3	Class 2	Class 1
Preliminary Treatment				
Screening	X	X	X	X
Comminution	X	X	X	X
Grit removal	X	X	X	X
Flow equalization	X	X	X	X
Primary Treatment				
Clarifiers	X	X	X	X
Odor control	X	X	X	X
Secondary Treatment				
Fixed-film reactors (trickling filters, RBCs)	X	X	X	X
Activated sludge	X	X	X	X
Stabilization ponds without aeration	X	X	X	X
Stabilization ponds with aeration	X	X	X	X
Advanced (Tertiary) Treatment				
Polishing ponds	X	X	X	X
Chemical/physical advanced waste treatment without secondary (carbon adsorption, air stripping, chemical coagulation, precipitation, etc.)		X	X	X
Chemical/physical advanced waste treatment following secondary (carbon adsorption, air stripping, chemical coagulation, precipitation, etc.)		X	X	X
Biological or chemical/biological advanced waste treatment (nitrification, denitrification, phosphorus removal, etc.)	X	X	X	X
Nitrification by designed extended aeration only		X	X	X
Ion exchange for advanced waste treatment		X	X	X
Reverse osmosis, electrodialysis and other membrane filtration		X	X	X
Media filtration		X	X	X

(continued)

Core Competencies (continued)

Monitor, Evaluate and Adjust Treatment Processes *(continued)*	Class 4	Class 3	Class 2	Class 1
Chemical Addition				
Add dry chemicals	X	X	X	X
Add gaseous chemicals		X	X	X
Add liquid chemicals	X	X	X	X
Disinfection				
Dechlorination	X	X	X	X
Gas chlorination		X	X	X
Hypochlorination	X	X	X	X
Ultraviolet irradiation	X	X	X	X
Effluent discharge and reuse	X	X	X	X
Solids Handling				
Conditioning (chemical, thermal, elutriation)	X	X	X	X
Dewatering (filtration, centrifugation, drying beds)	X	X	X	X
Stabilization (digestion, thermal, chemical)	X	X	X	X
Thickening (gravity, flotation, centrifugation, filtration)		X	X	X
Volume reduction (drying, incineration, composting)	X	X	X	X

Required Capabilities:

- Ability to adjust chemical feed rates, flow patterns, and process units
- Ability to calculate dosage rates
- Ability to confirm chemical strength
- Ability to evaluate, diagnose, and troubleshoot process units
- Ability to interpret Material Safety Data Sheets
- Ability to maintain processes in normal operating conditions
- Ability to measure and prepare chemicals
- Ability to perform basic math and process control calculations
- Knowledge of biological science
- Knowledge of flow measurement principles
- Knowledge of general chemistry
- Knowledge of general electrical and mechanical principles
- Knowledge of normal chemical range
- Knowledge of personal protective equipment
- Knowledge of physical science
- Knowledge of principles of measurement
- Knowledge of proper application, handling, and storage of chemicals
- Knowledge of regulations and policies
- Knowledge of sludge management practices
- Knowledge of wastewater treatment concepts and treatment processes

Core Competencies (continued)

Evaluate and Maintain Equipment	Class 4	Class 3	Class 2	Class 1
Evaluate Equipment				
Check and evaluate capacity of equipment	X	X	X	X
Inspect equipment for abnormal conditions	X	X	X	X
Measure and evaluate head loss	X	X	X	X
Read and evaluate chart and meter results	X	X	X	X
Read and evaluate gauges	X	X	X	X
Perform Maintenance				
Backflow prevention devices	X	X	X	X
Blowers and compressors	X	X	X	X
Boilers		X	X	X
Chemical feeders	X	X	X	X
Drives	X	X	X	X
Engines (gas, diesel)	X	X	X	X
Fittings/Piping	X	X	X	X
Generators	X	X	X	X
HVAC equipment			X	X
Hydraulic equipment			X	X
Instrumentation	X	X	X	X
Motors	X	X	X	X
Pneumatic equipment			X	X
Pumps	X	X	X	X
Tanks and infrastructure	X	X	X	X
Traps and drains	X	X	X	X
Valves	X	X	X	X

Required Capabilities:

- Ability to assign work to proper trade
- Ability to calibrate equipment
- Ability to diagnose and troubleshoot equipment
- Ability to differentiate between preventive and corrective maintenance
- Ability to discriminate between normal and abnormal conditions
- Ability to monitor and adjust equipment
- Ability to order necessary spare parts
- Ability to perform basic math
- Ability to perform general maintenance
- Ability to read and interpret O&M manuals
- Knowledge of facility operation and maintenance
- Knowledge of general electrical and mechanical principles
- Knowledge of hydraulic and pneumatic principles
- Knowledge of internal combustion engines
- Knowledge of lubricant and fluid characteristics
- Knowledge of process control instrumentation
- Knowledge of safety regulations
- Knowledge of start-up and shut-down procedures

Core Competencies (continued)

Operate Equipment	Class 4	Class 3	Class 2	Class 1
Backflow prevention devices	X	X	X	X
Blowers and compressors	X	X	X	X
Boilers		X	X	X
Chemical feeders	X	X	X	X
Computers	X	X	X	X
Drives	X	X	X	X
Electronic testing equipment	X	X	X	X
Engines	X	X	X	X
Flow meters	X	X	X	X
Generators	X	X	X	X
Hand and power tools	X	X	X	X
Heat exchangers		X	X	X
Heavy vehicles		X	X	X
HVAC equipment			X	X
Hydrants		X	X	X
Hydraulic equipment			X	X
Instrumentation	X	X	X	X
Lifting equipment		X	X	X
Motors	X	X	X	X
Odor control equipment	X	X	X	X
Pneumatic equipment	X	X	X	X
Pumps	X	X	X	X
Tanks and infrastructure	X	X	X	X
Traps and drains	X	X	X	X
Valves	X	X	X	X

Required Capabilities:

- Ability to monitor, evaluate and adjust equipment
- Ability to read and interpret O&M manuals
- Knowledge of function of tools
- Knowledge of general electrical and mechanical principles
- Knowledge of hydraulic and pneumatic principles
- Knowledge of regulations
- Knowledge of safety procedures
- Knowledge of start-up and shut-down procedures
- Knowledge of wastewater treatment concepts

Core Competencies (continued)

COLLECT SAMPLES AND INTERPRET LABORATORY ANALYSES	Class 4	Class 3	Class 2	Class 1
Bioassay			X	X
Biochemical oxygen demand	X	X	X	X
Carbon dioxide			X	X
Chemical oxygen demand			X	X
Chlorine residual	X	X	X	X
Coliform	X	X	X	X
Dissolved oxygen	X	X	X	X
Dissolved solids	X	X	X	X
Metal analysis	X	X	X	X
Microbiological	X	X	X	X
Nitrogen (Ammonia, Nitrate, Nitrite, Total Kjeldahl)	X	X	X	X
pH	X	X	X	X
Phosphorus	X	X	X	X
Settleability testing	X	X	X	X
Solids	X	X	X	X
Temperature	X	X	X	X
Volatile acids		X	X	X

Required Capabilities:

- Ability to calibrate instruments
- Ability to follow written procedures
- Ability to interpret Material Safety Data Sheets
- Ability to perform laboratory calculations
- Ability to recognize abnormal analytical results
- Knowledge of approved analytical procedures
- Knowledge of biological science
- Knowledge of chain of custody
- Knowledge of general chemistry
- Knowledge of laboratory equipment and procedures
- Knowledge of normal characteristics of wastewater
- Knowledge of physical science
- Knowledge of principles of measurement
- Knowledge of proper chemical handling and storage
- Knowledge of quality control and assurance practices
- Knowledge of safety regulations
- Knowledge of sampling and preservation procedures

Core Competencies (continued)

PERFORM LABORATORY ANALYSES	Class 4	Class 3	Class 2	Class 1
Ammonia/Total Kjeldahl		X	X	X
Bioassay			X	X
Biochemical oxygen demand	X	X	X	X
Carbon dioxide			X	X
Chemical oxygen demand	X	X	X	X
Chlorine residual	X	X	X	X
Coliform	X	X	X	X
Dissolved oxygen	X	X	X	X
Dissolved solids	X	X	X	X
Microbiological		X	X	X
Nitrate/Nitrate			X	X
Oxygen uptake/Respiration rate			X	X
pH	X	X	X	X
Phosphorus		X	X	X
Settleability testing	X	X	X	X
Solids	X	X	X	X
Temperature	X	X	X	X
Volatile acids		X	X	X

Required Capabilities:

- Ability to calibrate instruments
- Ability to follow written procedures
- Ability to interpret Material Safety Data Sheets
- Ability to perform laboratory calculations
- Ability to recognize abnormal analytical results
- Knowledge of approved analytical procedures
- Knowledge of biological science
- Knowledge of chain of custody
- Knowledge of general chemistry
- Knowledge of laboratory equipment and procedures
- Knowledge of normal characteristics of wastewater
- Knowledge of physical science
- Knowledge of principles of measurement
- Knowledge of proper chemical handling and storage
- Knowledge of quality control and assurance practices
- Knowledge of safety regulations
- Knowledge of sampling and preservation procedures

Core Competencies (continued)

Perform Security, Safety and Administrative Procedures	Class 4	Class 3	Class 2	Class 1
Perform Security and Safety Procedures				
Bloodborne pathogens	X	X	X	X
Chemical handling	X	X	X	X
Confined space entry	X	X	X	X
Electrical hazards	X	X	X	X
Facility upset	X	X	X	X
Fire safety	X	X	X	X
Lock-out/tag-out	X	X	X	X
Natural and manmade disasters	X	X	X	X
Personal protective equipment	X	X	X	X
Respiratory protection	X	X	X	X
Spill response		X	X	X
Transportation	X	X	X	X
Terrorism	X	X	X	X
Perform Administrative Procedures				
Administer compliance, emergency preparedness and safety program		X	X	X
Develop operation and maintenance plan		X	X	X
Plan and organize work activities		X	X	X
Record and evaluate data	X	X	X	X
Respond to complaints	X	X	X	X
Write regulatory authority reports	X	X	X	X

Required Capabilities:

- Ability to assess likelihood of disaster occurring
- Ability to communicate safety hazards verbally and in writing
- Ability to conduct meetings and training programs
- Ability to coordinate emergency response with other organizations
- Ability to evaluate facility performance
- Ability to evaluate proposals
- Ability to interpret and transcribe data
- Ability to perform basic math
- Ability to perform impact assessment of change
- Ability to recognize unsafe work conditions
- Ability to review reports
- Ability to select and operate safety equipment
- Ability to translate technical language into common terminology
- Ability to write plans, policies and procedures
- Ability to write reports
- Knowledge of emergency plans
- Knowledge of facility operation and maintenance
- Knowledge of local codes and ordinances
- Knowledge of monitoring and reporting requirements
- Knowledge of potential causes and impact of disasters on facility
- Knowledge of principles of management
- Knowledge of principles of public relations
- Knowledge of recordkeeping functions & policies
- Knowledge of regulations

Virginia Wastewater Treatment Examination Formula Sheet

1. Circumference, Area, Volume

a. Circumference	C = 3.1416 x Diameter
b. Perimeter	P = [2 x Length] + [2 x Width]
c. Area	
Rectangle	Area = Length x Width
Circle	Area = 0.785 x Diameter x Diameter
Triangle	$\text{Area} = \frac{1}{2} \times \text{Base} \times \text{Height}$
d. Volume	
Rectangle	Volume = Length x Width x Depth
Cylinder	Volume = 0.785 x Diameter x Diameter x Depth
Cone	Volume = 0.262 x Diameter x Diameter x Height
Sphere	Volume = 0.524 x Diameter x Diameter x Diameter

2. Conversion Factors

a. ft^3 to Gallons	Volume, Gallons = Volume, ft^3 x 7.48 Gallons / ft^3
b. Gallons to Pounds	Pounds = Gallons x 8.34 lbs/Gallon
c. mg/L to Pounds	Pounds = Concentration, mg/L x Tank Volume, MG x 8.34 lbs / MG / mg/L
d. mg/L to Pounds/Day	Pounds/Day = Concentration, mg/L x Flow, MGD x 8.34 lbs / MG / mg/L
e. mg/L to Kilograms/Day	Kilograms/Day = Conc., mg/L x Flow, MGD x 3.785 lbs / MG / mg/L
f. mg/KG to Pounds/Ton	Pounds/Ton = Concentration, mg/KG x 0.002 lbs / ton / mg/KG
g. Pounds to mg/L	$\text{Concentration} = \frac{\text{Quantity, lbs}}{(\text{Tank Volume, MG} \times 8.34 \text{ lbs / mg/L / MG})}$
h. Pounds/day to mg/L	$\text{Concentration} = \frac{\text{Quantity, lbs}}{(\text{Flow, MGD} \times 8.34 \text{ lbs / mg/L / MG})}$
i. Pounds/day to MGD	$\text{Flow, MGD} = \frac{\text{Quantity, lbs / day}}{(\text{Concentration, mg/L} \times 8.34 \text{ lbs / mg/L / MG})}$

3. Flow

a. MGD to GPD	Flow, GPD = Flow, MGD x 1,000,000 gallons / MG
b. MGD to GPM	$\text{Flow, GPM} = \frac{\text{Flow, MGD} \times 1{,}000{,}000 \text{ gallons / MG}}{1{,}440 \text{ minute / Day}}$
c. MGD to CFS	Flow, cfs = Flow, MGD x 1.55 cfs / MGD

Provided by Virginia Department of Environmental Quality

4. Chemical Weight

Using Specific Gravity	Weight, lbs / Gallon = Specific Gravity x 8.34 lbs / Gallon

5. Population Equivalent

$$\text{P.E., People} = \frac{BOD_5\text{, mg/L x Flow, MGD x 8.34 lbs / mg/L /MG}}{\text{0.17 lbs } BOD_5 \text{ / Person / Day}}$$

6. Percent to Decimal Percent

$$\text{Percent (Decimal)} = \frac{\text{Percent}}{100}$$

7. Percent Removal

a. Based on Concentration	$\% \text{ Removal} = \frac{[\text{ Influent Concentration} - \text{ Effluent Concentration }] \text{ x } 100}{\text{Influent Concentration}}$
b. Based on Quantity (lbs, lbs/day, KG or KG/day)	$\% \text{ Removal} = \frac{[\text{ Influent Quantity} - \text{ Effluent Quantity }] \text{ x } 100}{\text{Influent Quantity}}$

8. Hydraulic Detention Time

a. HDT, Minutes	$\text{HDT, Minutes} = \frac{\text{Tank Volume, } ft^3 \text{ x 7.48 gal / } ft^3 \text{ x 1,440 Minutes / Day}}{\text{Flow, Gallons / Day}}$
b. HDT, Hours	$\text{HDT, Hours} = \frac{\text{Tank Volume, } ft^3 \text{ x 7.48 gal / } ft^3 \text{ x 24 Hours / Day}}{\text{Flow, Gallons / Day}}$
c. HDT, Days	$\text{HDT, Days} = \frac{\text{Tank Volume, } ft^3 \text{ x 7.48 gal / } ft^3}{\text{Flow, Gallons / Day}}$

9. Flow Measurement

a. Flow, (Fill and Draw), GPM	$\text{Flow Rate, GPM} = \frac{\text{Volume Added or Removed, Gallons}}{\text{Time, Minutes}}$
b. Flow (Velocity), cfs	Flow (Q), cfs = Channel Width, ft x Water Depth, ft x Velocity, fps

10. Grit Removal

a. Velocity (float method)	$Velocity, fps = \frac{Distance Traveled, ft}{Time Required, Seconds}$
b. Velocity	$Velocity, fps = \frac{Flow, MGD \times 1.55\ cfs / MGD}{Channels in Service \times Channel Width, ft \times Water\ Depth, ft}$
c. Settling Time*	$Settling\ Time, Seconds = \frac{Water\ Depth, Feet}{Settling\ Velocity, fps}$
d. Required Channel Length*	$Channel Length, ft = \frac{Water\ Depth, Ft \times Water\ Velocity, fps}{Settling Velocity, fps}$
* The settling velocity must be given or determined experimentally.	

11. Settling

a. Weir Overflow Rate	$Weir\ Overflow\ Rate, GPD / ft = \frac{Flow, Gallon / Day}{Weir\ Length, ft}$
b. Surface Loading Rate	$Surface\ Loading\ Rate, GPD / ft^2 = \frac{Flow, Gallons / Day}{Settling\ Tank\ Area, ft^2}$
c. Solids Loading Rate	$SLR, lbs / day / ft^2 = \frac{Influent\ TSS, mg/L \times Flow, MGD \times 8.34\ lbs / mg/L / MG}{Settling\ Tank\ Area, ft^2}$

12. Ponds

a. Area in Acres	$Area, acres = \frac{Area, ft^2}{43,560\ ft^2 / acre}$
b. Volume in Acre-Feet	$Pond\ Volume, Acre\ Feet = \frac{Length, ft \times Width, ft \times Depth, ft}{43,560 ft^3 / Acre\ Foot}$
c. Flow in Acre-Feet/Day	$Flow, Acre\ Ffeet / Day = Flow, MGD \times 3.069\ Acre\ Feet / MG$
d. Flow, Acre-Inches/Day	$Flow, Acre\ Inches / Day = Flow, MGD \times 36.8\ Acre\ Inches / MG$
e. Hydraulic Detention Time, Days	$Hydraulic\ Detention Time, Days = \frac{Pond\ Volume, Acre\ Feet}{Influent\ Flow, Acre\ Feet / Day}$
f. Hydraulic Loading	$Hydraulic\ Loading, Inches / Day = \frac{Influent\ Flow, Acre\ Inches / Day}{Pond\ Area, Acres}$
g. Organic Loading	$O.L., lbs\ BOD_5 / Acre / Day = \frac{BOD_5, mg/L \times Flow_{in}, MGD \times 8.34\ lbs / mg/L / MG}{Pond\ Area, Acres}$
h. Population Loading	$P.L., People / Acre / Day = \frac{Population\ Served\ by\ System, People}{Pond\ Area, Acres}$

13. Trickling Filter

a. Total Flow (given flows)	$\text{Total Flow, MGD} = \text{Influent Flow, MGD} + \text{Recirculation Flow, MGD}$
b. Total Flow (given ratio)	$\text{Total Flow, MGD} = \text{Influent Flow, MGD} \times (1.0 + \text{Recirculation Rate})$
c. Hydraulic Loading	$\text{Hydraulic Loading, GPD} / ft^2 = \dfrac{\text{Total Flow To Filter, GPD}}{\text{Filter Area}, ft^2}$ Total flow always includes recirculated flow.
d. Organic Loading	$\text{O L, lbs } BOD_5 / \text{day} / 1{,}000\,ft^3 = \dfrac{BOD_5 \text{ IN, mg/L} \times Flow_{in}\text{, MGD} \times 8.34 \times 1{,}000}{\text{Filter Volume}, ft^3}$ Organic loading does not include recirculated flows

14. Rotating Biological Contactors

a. Soluble BOD	$\text{SBOD, mg/L} = \text{Total } BOD_5\text{, mg/L} - (\text{'K' Factor} \times \text{Influent TSS mg/L})$
b. Total Media	$\text{Total Media/Train}, ft^2 = \sum(\text{Stage}_1, ft^2 + \text{Stage}_2, ft^2 + \ldots + \text{Stage}_n, ft^2)$ $\text{Total Media}, ft^2 = \sum(\text{Media}_{Train\,1}, ft^2 + \text{Media}_{Train\,2}, ft^2 + \ldots + \text{Media}_{Train\,n}, ft^2)$
c. Hydraulic Loading	$\text{Hydraulic Loading, GPD} / ft^2 = \dfrac{\text{Influent Flow MGD} \times 1{,}000{,}000\text{gal/MG}}{\text{Total Media Area}, ft^2}$
d. Soluble Organic Loading	$\text{SOL, lbs} / 1{,}000\,ft^2 / \text{Day} = \dfrac{SBOD_{in}\text{, mg/L} \times \text{Flow, MGD} \times 8.34 \times 1{,}000}{\text{Total Media Area}, ft^2}$
e. Total Organic Loading	$\text{TOL, lbs} / 1{,}000\,ft^2 / \text{Day} = \dfrac{\text{Total } BOD_{in}\text{, mg/L} \times \text{Flow, MGD} \times 8.34 \times 1{,}000}{\text{Total Media Area}, ft^2}$

15. Activated Sludge

a. Settled Sludge Volume	$\text{SSV, mL/L} = \dfrac{\text{Settled Sludge Volume (SSV), mL} \times 1{,}000\text{ mL/L}}{\text{Sample Volume, mL}}$
b. Settled Sludge Volume	$\%\,\text{SSV} = \dfrac{\text{Settled Sludge Volume (SSV), mL} \times 100}{\text{Sample Volume, mL}}$
c. Return Rate (By SSV)	$\text{Return, MGD} = \dfrac{SSV_{30}}{1000\ \ SSV_{30}} \times Flow_{in}\text{, MGD}$
d. Return Rate (By SVI)	$\text{RASSS, mg/L} = \dfrac{1{,}000{,}000}{\text{SVI}}$ $\%\ \text{Return} = \dfrac{Flow_{in} \times \text{MLSS, mg/L}}{\text{RASSS, mg/L}\ \ \text{MLSS, mg/L}}$
e. Return Rate (Clarifier Mass Balance)	$\dfrac{[\text{MLSS, mg/L} \times (Flow_{In}\text{, MGD} + \text{RAS Flow, MGD})] + (\text{WAS Flow, MGD} \times \text{WASSS, mg/L})}{\text{RASSS, mg/L} + \text{MLSS, mg/L}}$

15 . Activated Sludge (continued)

f. Clarifier Solids (Core Sample)	$Solids_C$, lbs = Core Sample TSS, mg/L x $Volume_C$ MG x 8.34 lbs / mg/L / MG
g. Clarifier Solids (MLSS)	$Solids_C$ = MLSS, mg/L x $Volume_C$, MG x 8.34 lbs / mg/L / MG
h. Clarifier Solids (MLSS and RASSS)	$Solids_C, lbs = \left(\frac{MLSS, mg/L + RASSS, mg/L}{2}\right) x\ Volume_C, MG \times 8.34\ lbs / mg/L / MG$ C = Clarifier or Settling Tank MLSS = Mixed Liquor Suspended Solids in milligrams / Liter RASSS = Return Activated Sludge Suspended Solids in milligrams / Liter
i. Sludge Volume Index	$SVI = \frac{Settled\ Sludge\ Volume, (SSV)_{30\ minutes} x\ 1{,}000}{MLSS, mg/L}$
j. F:M Ratio	$\frac{Aeration\ Influent\ COD\ or\ BOD_5, mg/L \times Aeration\ Influent\ Flow, MGD \times 8.34}{MLVSS, mg/L \times Aeration\ Volume, MG \times 8.34}$
k. Desired MLVSS, (lbs)	$MLVSS, lbs = \frac{Primary\ Effluent\ BOD_5\ or\ COD, mg/L \times Flow, MGD \times 8.34}{Desired\ F:M\ Ratio}$
l. Desired MLVSS (mg/L)	$MLVSS, mg/L = \frac{Desired\ MLVSS, lbs}{(Aeration\ Volume, MG \times 8.34)}$
m. Waste Volatile Solids (Based on F:M)	Waste, lbs = Actual MLVSS, lbs – Required MLVSS, lbs
n. Waste Rate, MGD (Based on F:M)	$Waste, MGD = \frac{Waste\ Volatile\ Solids, lbs / day}{(Waste\ Volatile\ Concentration, mg/L \times 8.34)}$
o. MCRT, Days	$\frac{[MLSS, mg/L \times (Aeration, MG + Settling, MG) \times 8.34]}{(WASSS, mg/L \times WAS, MGD \times 8.34) + (TSS_{out}, mg/L \times Flow_{out}, MGD \times 8.34)}$
p. Waste Solids, lbs/day (Based on MCRT)	$\left[\frac{(MLSS, mg/L \times (Aeration\ Vol., MG + Settling\ Vol., MG) \times 8.34)}{Desired\ MCRT, days}\right] - (TSS_{out}, mg/L \times Flow_{out}, MGD \times 8.34)$
q. Waste Rate, MGD (Based on MCRT)	$Waste, MGD = \frac{Waste\ Solids, lbs / day}{Waste\ Activated\ Sludge\ Concentration, mg/L \times 8.34}$
r. Waste Rate, GPM	$Waste\ Rate, gpm = \frac{Waste\ Rate, MGD \times 1{,}000{,}000\ gal / MG}{1{,}440\ minutes / day}$

16. Chemical Addition

a. Demand	Demand, mg/L = Dose, mg/L – Residual, mg/L
b. Dose, mg/L	$Dose, mg/L = \frac{Feed\ Rate, lbs / day}{Daily\ Flow, MGD \times 8.34\ lbs / mg/L / MG}$
c. Required Chemical (Feed Rate, lbs/day)	$Required\ Chemical_{industrial}, lbs / Day = \frac{Dose, mg/L \times Daily\ Flow, MGD \times 8.34\ lbs / mg/L / MG}{\%\ (decimal)\ Active\ Ingredient\ in\ Industrial\ Chemical}$

16. Chemical Addition (Continued)

d. Feed Rate, gpd	$\text{Feed, gpd} = \dfrac{\text{Required Chemical}_{Industrial}\text{, lbs/day}}{\text{Weight / Gallon of Chemical}_{Industrial}\text{, lbs / gal}}$
e. Feed Rate, gpm	$\text{Feed, gpm} = \dfrac{\text{Required Chemical}_{Industrial}\text{, lbs/day}}{\text{Weight / Gallon of Chemical}_{Industrial}\text{, lbs / gal x 1,440 minutes / day}}$
f. Feed Rate, mL/minute	$\text{Feed, mL / minute} = \dfrac{\text{Required Chemical}_{industrial}\text{, lbs / day x 3,785 mL / gal}}{\text{Weight / Gallon of Chemical}_{Industrial}\text{, lbs / gal x 1,440 min / day}}$
g. Supply Required	$\text{Required Supply, containers} = \dfrac{\text{Feed Rate, lbs / day x Days Supply Required, days}}{\text{Weight of Chemical in a Full Container, lbs / container}}$
h. Supply on Hand	$\text{Supply on Hand, days} = \dfrac{\text{\# Full Containers x Weight of Chemical in a Full Container, lbs / container}}{\text{Chemical Feed Rate, lbs / day}}$
i. Increases, (price, usage, or for safety)	$\text{Increase} = \text{Current Amount x [1.0 + \% (decimal) Increase]}$
j. Chemical Cost	
k. Chemical Makeup (dry chemical)	$\text{Required, lbs} = \dfrac{\text{\% Active Chemical}_{working}\text{ x Volume, gallons x 8.34 lbs / gallon}}{\text{\% Active Chemical}_{supply}}$
l. Chemical Makeup (solution)	$\text{Volume}_{Makeup} = \dfrac{\text{Concentraton}_{Working}\text{ x Volume}_{Working}}{\text{Concentraton}_{Makeup}}$
m. Active Ingredient	$\text{Chemical Used}_{Active\ Ingredient} = \text{Chemical Used, lbs x \% Active Ingredient}$

17. Solids Pumping

a. Estimated Pump Rate (gallons/minute)	$\text{Rate, gpm} = \dfrac{(\text{TSS}_{in} - \text{TSS}_{out})\text{ x Flow, MGD}}{\text{\% Solids x Pump Time, minutes / day}}$
b. Gallon pumped GPD	GPD = Pump Rate, gpm x Cycles, Cycles / day x Cycle Time, minutes / cycle
c. Solids Pumped lbs/day	Solids, lbs / day = Solids Volume, gpd x 8.34 lbs / gal × % (decimal) Solids
d. Volatile Solids Pumped, lbs/day	Volatile Solids, lbs / day = Solids Volume, gpd x 8.34 lbs / gal x % Solids x % Volatile Matter All % values must be in decimal form.

18. Thickening

a. Solids Loading Rate (SLR) lbs/day/ft^2	$\text{SLR, lbs / day / ft}^2 = \dfrac{\text{TSS}_{in}\text{, mg / L x Flow}_{in}\text{, MGD x 8.34 lbs / gallon}}{\text{Thickener Area, ft}^2}$
b. Solids Loading Rate (SLR) lbs/hour/ft^2	$\text{Solids Loading, lbs / hr / ft}^2 = \dfrac{\text{Solids Applied, lbs / hour}}{\text{Thickener Area, ft}^2}$

18. Thickening (continued)	
c. Solids Volume Ratio (SVR)	$SVR = \frac{\text{Solids Blanket Volume, gallons}}{\text{Thickener Influent Flow, gallons / day}}$
d. Hydraulic Loading	$\text{Hydraulic Loading, gpd / ft}^2 = \frac{\text{Total Thickener Influent Flow, gpd}}{\text{Thickener Area, ft}^2}$
e. Air : Solids Ratio	$\text{Air : Solids Ratio} = \frac{\text{Air Flow Rate, ft}^3\text{ / minute x 0.075 lbs / ft}^3}{\text{Sludge Flow, gpm x \% Solids x 8.34 lbs / gallon}}$
f. Concentration Factor	$\text{Concentration Factor} = \frac{\text{\% Solids Thickener Sludge}_{out}}{\text{\% Solids Thickener Sludge}_{in}}$

19. Aerobic Digestion

a. Volatile Solids Loading lbs/day/ft^3	$\text{Volatile Solids Loading, lbs /day / ft}^3 = \frac{\text{Volatile Solids Added, lbs / day}}{\text{Digester Volume, ft}^3}$
b. Digestion Time (based on flow)	$\text{Digestion Time, days} = \frac{\text{Digester Volume, gallons}}{\text{Influent Flow, gpd}}$
c. Digestion Time (based on solids)	$\text{Digestion Time, days} = \frac{\text{Digester Solids, pounds}}{\text{Influent Solids, lbs / day}}$
d. Chemical Requirement	$\text{Chemical Req'd} = \frac{\text{Chemical Used}_{lab}\text{, mg x Digester Volume, MG x 8.34 lbs / mg / L /MG}}{\text{Sludge Volume}_{lab}\text{, Liters}}$
e. Volatile Matter Reduction	$\text{\% V. M. Reduction} = \frac{(\text{\% V.M.}_{in} - \text{\% V.M.}_{out}) \text{ x } 100}{[\text{\% V.M.}_{in} - (\text{\% V.M.}_{in} \text{ x \% V.M.}_{out})]}$

20. Anaerobic Digestion

a. Seed Volume	$\text{Seed, gallons} = \text{Digester Volume, gallons x Desired \% Seed Volume}$
b. Volatile Solids Loading	$\text{Volatile Solids Loading, lbs /day / ft}^3 = \frac{\text{Volatile Solids Added, lbs / day}}{\text{Digester Volume, ft}^3}$
c. Volatile Acids/ Alkalinity Ratio	$\text{V. A. : Alkalinity Ratio} = \frac{\text{Volatile Acids, mg / L}}{\text{Alkalinity, mg / L}}$
d. Chemical Requirement	$\text{Chemical Req'd} = \frac{\text{Chemical Used}_{lab}\text{, mg x Digester Volume, MG x 8.34 lbs / mg / L /MG}}{\text{Sludge Volume}_{lab}\text{, Liters}}$
e. Volatile Matter Reduction	$\text{\% V. M. Reduction} = \frac{(\text{\% V.M.}_{in} - \text{\% V.M.}_{out}) \text{ x } 100}{[\text{\% V.M.}_{in} - (\text{\% V.M.}_{in} \text{ x \% V.M.}_{out})]}$
f. Gas Production ft^3/Day	$\text{Gas, ft}^3 = \text{Volatile Solids}_{in}\text{, lbs / day x \% V. M. Reduction x Rate, ft}^3\text{ / lb V.M. Destroyed}$

21. Land Application

a. Solids Production (dry tons/year)	$\text{Solids, dt / year} = \dfrac{\text{Solids Produced, lbs / MG x Average Daily Flow, MGD x 365 days / year}}{\text{2,000 pounds/ ton}}$
b. Solids Production (wet tons/year)	$\text{Solids, wt / year} = \dfrac{\text{Solids Produced, lbs / MG x Average Daily Flow, MGD x 365 days / year}}{\text{\% (decimal) Solids x 2,000 pounds/ ton}}$
c. Plant Available Nitrogen (PAN) (lbs/dry ton)	$[(\text{Organic - N, mg / kg} \times f_1) + (\text{Ammonia - N, mg / kg} \times V_1)] \times 0.002$ f_1 = Mineralization Rate (assume 0.20) V_1 = Volatilization Rate Injected Sludge = 1.0 Incorporated Within 24 hrs = 0.85 Incorporated within 7 days = 0.70
d. Application Rate (nitrogen basis)	$\text{Application Rate, Dry Tons / Acre} = \dfrac{\text{Plant Required Nitrogen, lbs / acre}}{\text{Plant Available Nitrogen, lbs / dry ton}}$
e. Metals Loading lbs/acre	$\text{Loading, lbs / Acre} = \text{Concentraton, mg / kg} \times \text{Application Rate, D.T. / acre x 0.002 mg / kg / dry ton}$
f. Allowable Applications (Metals Basis)	$\text{Maximum Applications} = \dfrac{\text{Maximum Allowable Metals Loading, lbs / acre}}{\text{Metal Loading / Application, lbs / acre / application}}$
g. Site Life (metal basis)	$\text{Site Life} = \dfrac{\text{Allowable Applications}}{\text{Frequency, applications / year}}$

22. Pumping

a. Head to Pressure	$\text{Pressure, psi} = \text{Head, ft} \times 0.433 \text{ psi / ft}$
b. Pressure to Head	$\text{Head, ft} = \text{Pressure, psi} \times 2.31 \text{ ft / psi}$
c. Work	$\text{Work, ft-lbs} = \text{Weight, lbs} \times \text{Height, ft}$
d. Power	$\text{Power, ft-lbs / minute} = \dfrac{\text{Work, ft-lbs}}{\text{Time, minutes}}$
e. Static Head, ft	$\text{Static Head, ft} = \text{Discharge Tank Elevation, ft} - \text{Supply Tank Elevation, ft}$
f. Total Dynamic Head	$\text{TDH, ft.} = \text{Static Head, ft.} + \text{Friction Head, ft.} + \text{Velocity Head, ft.}$ TDH = Total Dynamic Head
g. Horsepower	$\text{Horsepower} = \dfrac{\text{Power, ft-lbs / min}}{\text{33,000 ft-lbs / minute / HP}}$
h. Water Horsepower	$\text{Water Horsepower, whp} = \dfrac{\text{Pump Rate, gpm x Total Head, ft x 8.34 lbs / gal.}}{\text{33,000 ft lbs / minute / hp}}$
i. Brake Horsepower	$\text{Brake Horsepower, bhp} = \dfrac{\text{Water Horsepower, HP}}{\text{\% Efficiency}_{pump}}$
j. Motor Horsepower	$\text{Motor Horsepower, mhp} = \dfrac{\text{Brake Horsepower, HP}}{\text{\% Efficiency}_{motor}}$

k. Centrifugal Pump Affinity Law	
Capacity	$\text{Flow}_2, \text{cfs} = \frac{\text{Pump Speed}_2}{\text{Pump Speed}_1} \times \text{Flow}_1, \text{cfs}$
Head	$\text{Head}_2 = \left(\frac{\text{Pump Speed}_2}{\text{Pump Speed}_1}\right)^2 \times \text{Head}_1$
Brake Horsepower	$\text{Bhp}_2 = \left(\frac{\text{Pump Speed}_2}{\text{Pump Speed}_1}\right)^3 \times \text{Bhp}_1$

23. Electrical Energy

a. Hp to kilowatts (kW)	*Kilowatts = Horsepower x 0.746 Kw / hp*
b. kW to kilowatt hrs	*Kilowatt Hour = Kilowatts Used x Hours Operated*
c. Power Cost	*Cost = Kilowatt hours used x Cost / Kilowatt*

24. Sampling

a. Composite Sample Volume, mL	$\text{Sample Volume}_T = \frac{\text{Plant Flow}_T,\ \text{MGD x Total Sample Required, mL}}{\text{\# Samples To Be Collected x Average Daily Flow, MGD}}$ *T = Sample Collection Time*
b. Proportioning Factor (PF)	$\text{Proportioning Factor} = \frac{\text{Total Sample Required, mL}}{\text{\# of Samples Collected x Average Daily Flow, MGD}}$
c. Sample Volume (Using PF)	$\text{Sample Volume, mL} = \text{Flow}_T \text{ x PF}$ *T = Time sample is collected.*

25. Alkalinity

a. Conventional	$\text{Alkalinity as } CaCO_3\text{, mg/L} = \frac{\text{A x N x 50,000}}{\text{Sample Volume, mL}}$ *A = Volume of Standard Acid Used* *N = Normality of Standard Acid*
b. Low Level	$\text{Alkalinity as } CaCO_3\text{, mg/L} = \frac{(\text{2B - C}) \text{ x N x 50,000}}{\text{Sample Volume, mL}}$ *B = Volume of Standard Acid Used to reach pH 4.3 - 4.5* *C = Total volume of Standard Acid for titration* *N = Normality of Standard Acid*

26. Hardness

a. EDTA Standardization	$EDTA, CaCO_3\ Equivalence\ (B) = \frac{Volume\ of\ CaCO_3\ Solution\ Titrated, mL}{EDTA\ Titrant\ Used, mL}$
b. Hardness, mg/L Calcium Carbonate	$Hardness(EDTA)\ as\ CaCO_3 = \frac{A \times B \times 1{,}000}{Sample\ Volume, mL}$ A = EDTA Used in Titration, mL B = EDTA $CaCO_3$ Equivalence, mL / mL

27. Ammonia Nitrogen

a. Nesslerization	$NH_3\ N, mg/L = \frac{A}{Sample\ Volume, mL} \times \frac{B}{C}$ A = Micrograms of N from calibration curve B = Volume of distillate collected C = Volume of distillate used for nesslerization Sample Volume = Original sample volume placed in distillation flask
b. Titration	$NH_3 - N, mg/L = \frac{(A - B) \times 280}{Sample\ Volume, mL}$ A = Volume of titrant used for sample B = Volume of titrant used for blank Sample Volume = Volume of sample used for titration

28. Biochemical Oxygen Demand

a. Unseeded Samples	$BOD_5, mg/L = \frac{(D.O._{Start}, mg/L - D.O._{Final}, mg/L) \times 300\ mL}{Sample\ Volume, mL}$
b. Seed Correction Factor	$Seed\ Correction, mg/L = \frac{BOD_{seed}}{300\ mL} \times mL\ Seed\ in\ the\ Sample\ Dilution$
c. Seeded Samples	$BOD_5, mg/L = \frac{[(D.O._{Start}, mg/L - D.O._{Final}, mg/L) - Seed\ Correction] \times 300\ mL}{Sample\ Volume, mL}$

29. Chemical Oxygen Demand

a. FAS Standardization (Open Reflux)	$FAS, Molarity = \frac{Volume\ of\ 0.0417M\ K_2Cr_2O_7, mL \times 0.25}{FAS\ Titrant\ Added, mL}$
b. FAS Standardization (Closed Reflux)	$FAS, Molarity = \frac{Volume\ 0.0167\ M\ K_2Cr_2O_7, mL \times 0.10}{FAS\ Titrant\ Added, mL}$
c. COD	$COD\ as\ mg\ O_2/L = \frac{(A - B) \times C \times 8000}{Sample\ Volume, mL}$ A = FAS Used For Blank, mL B = FAS Used For Sample, mL C = FAS Molarity

30. Total Residual Chlorine

a. Iodometric Direct Titration	$TRC, mg/L = \frac{(Titrant, mL - Blank, mL) \times Titrant Normality, N \times 35{,}450}{Sample, mL}$
b. Iodometric Back Titration (No Iodine correction)	$TRC, mg/L = \frac{PAO\ Added, mL\ (5 \times Iodine\ Used, mL)\ \times 200}{Sample\ Volume, mL}$
c. Iodine Correction	$Iodine Correction Factor = \frac{Iodine Normality_{actual}}{0.0282\ N}$
d. Iodometric Back Titration (With Iodine correction)	$TRC, mg/L = \frac{PAO\ Added, mL\ (5 \times Iodine\ Used, mL \times CF)\ \times 200}{Sample\ Volume, mL}$
e. Iodometric Back Titration Iodate Titrant	$TRC, mg/L = \frac{(Iodate Used_{blank} - Iodate Used_{sample})\ \times 200}{Sample Volume, mL}$

31. Dissolved Oxygen

a. Winkler Titration	$D.O., mg/L = \frac{Titrant, mL \times Normality \times 8{,}000}{Equivalent Sample Volume, mL}$ If $N = 0.0250$ & Sample Volume = 200 mL then : Titrant Used = D.O., mg / L

32. Fecal Coliform

a. Multiple Tube	$MPN/100\ mL = MPN_{chart} \times \frac{Sample Volume In First Dilution_{chart}}{Sample Volume in First Dilution_{sample}}$
~~b. Membrane Filtration~~	$Colonies/100\ mL = \frac{Colonies\ Counted}{Sample\ Volume, mL} \times 100\ mL$

33. Nitrate Nitrogen

a. Brucine Sulfate	$NO_3 - N, mg/L = \frac{NO_3 - N\ Concentraton, micrograms}{Sample Volume In Reaction Tube, mL}$
b. Cadmium Reduction	$NO_3 - N, mg/L = Nitrate/Nitrite, mg/L - Nitrite, mg/L$

34. Nitrite Nitrogen

a. Diazotization Diluted sample	$NO_2 - N = C \times \frac{V}{S}$ $C = NO_2$ - N Concentraton, mg / L V = Total volume after dilution, mL S = Sample volume in dilution, mL

35. Phosphorus

a. Phosphorus	$\text{Phosphorus, mg P / L} = \dfrac{\text{Phosphorus From Standard Curve, mg} \times 1{,}000}{\text{Sample Volume, mL}}$

36. Total Suspended Solids

a. TSS, mg/L	$\text{Total Suspended Solids, mg / L} = \dfrac{(A - B) \times 1{,}000 \text{ mg / gram} \times 1{,}000 \text{ mL / L}}{\text{Sample Volume, milliliters}}$ A = Weight of Dried Solids, Filter & planchet or dish in grams B = Tare Weight (Dried Filter & planchet or dish) in grams

37. Total Kjeldahl Nitrogen

a. Nesslerization	$\text{TKN} - \text{N, mg / L} = \dfrac{A}{\text{Sample Volume, mL}} \times \dfrac{B}{C}$ A = Micrograms of N from calibration curve B = Volume of distillate collected C = Volume of distillate used for nesslerization Sample Volume = Original sample volume placed in distillation flask
b. Titration	$\text{TKN} - \text{N, mg / L} = \dfrac{(A - B) \times 280}{\text{Sample Volume, mL}}$ A = Volume of titrant used for sample B = Volume of titrant used for blank Sample Volume = Volume of sample used for titration

38. Total Volatile Suspended Solids

a. TVSS, mg/L	$\text{Volatile Solids, mg / L} = \dfrac{(A - C) \times 1{,}000 \text{ mg / gram} \times 1{,}000 \text{ mL / L}}{\text{Sample Volume, milliliters}}$ A = Weight of Dried Solids & Support C = Weight of Ash & Support

39. Residual (Sludge) Solids Tests

a. % Solids	$\%\text{Solids} = \dfrac{\text{Dry Solids, grams}}{\text{Residual (Solids \& Water), grams}} \times 100$
b. % Volatile Matter	$\%\text{Volatile Matter} = \dfrac{(\text{Dry Solids, grams} - \text{Ash, grams})}{\text{Dry Solids, grams}} \times 100$
c. % Moisture	$\%\text{Moisture} = \dfrac{\text{Residual (Solids \& Water), grams} - \text{Dry Solids, grams}}{\text{Residual (Solids \& Water), grams}} \times 100$ or $\%\text{Moisture} = 100 - \%\text{Solids}$

40. VPDES Reporting

a. Average Monthly Concentration	$AMC, mg/L = \frac{\Sigma(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{Tests during month})}$
b. Average Weekly Concentration	$AWC, mg/L = \frac{\Sigma(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{tests during calendar week})}$
c. Average Daily Concentration	$ADC, mg/L = \frac{\Sigma(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{Tests during day})}$
d. Average Hourly Concentration	$AHC, mg/L = \frac{\Sigma(Test_1 + Test_2 + Test_3 + ... + Test_n)}{N(\text{tests during 60 minute period})}$
e. Daily Quantity	$DailyQuantity, KG/Day = Conc., mg/L \times Flow, MGD \times 3.785\ lbs/MG/mg/L$ $Conc. = \text{Individual Test Result in } mg/L$ $Flow = \text{Flow on day sample was collected in MGD.}$
f. Average Monthly Quantity	$AMQ, KG/day = \frac{\Sigma(DQ_1 + DQ_2 + DQ_3 + ... + DQ_n)}{N(\text{Tests during month})}$
g. Average Weekly *Quantity	$AWQ, KG/day = \frac{\Sigma(DQ_1 + DQ_2 + DQ_3 + ... + DQ_n)}{N(\text{tests during calendar week})}$
h. Geometric Mean (Xy)	$\text{Geometric Mean} = \sqrt[n]{Test_1 \times Test_2 \times Test_3 \times \ldots \times Test_n}$
i. Geometric Mean (log)	$\text{Geometric Mean} = Antilog\left[\frac{(\log X_1 + \log X_2 + \log X_3 + \ldots + \log X_n)}{N, \text{Number of Tests}}\right]$

41. Nutrient General Permit Reporting

a. Daily Loading, lbs/day	$\text{Daily Loading lbs/day} = \text{Concentraton, mg/L} \times \text{Flow, MGD} \times 8.3438$
b. Average Monthly Load	$\text{Average Monthly Load} = \frac{\sum \text{Daily Loading lbs/day}}{\text{Number of Days samples were collected}}$
c. Monthly Load	$\text{Monthly Load} = \text{Average Monthly Load} \times \text{Number of Days in Month}$
d. Annual Load, Year to Date	$\text{Annual Load, Year to Date} = \sum \text{Monthly Load}_{\text{January}} + \ldots + \text{Monthly Load}_{\text{current month}}$
e. Annual Load	$\text{Annual Load, lbs} = \sum \text{Monthly Load}_{\text{Jan}} + \ldots + \text{Monthly Load}_{\text{Dec}}$
f. Monthly Concentration	$\text{Monthly Concentraton} = \frac{\sum \text{Daily Concentraton}}{\text{Number of days samples were collected}}$
g. Average Annual Concentration Year to Date	$\text{Annual Concentraton, YTD} = \frac{\sum \text{Average Conc}_{\text{January}} + \ldots + \text{Average Conc}_{\text{Current Month}}}{\text{Number of Months}}$
h. Average Annual Concentration	$\text{Annual Concentraton} = \frac{\sum \text{Average Conc}_{\text{January}} + \ldots + \text{Average Conc}_{\text{December}}}{12}$

All percents (%) must be converted to decimal percent before use.

Σ = summation (adding all of the specified data points).

Provided by Virginia Department of Environmental Quality

SPECIAL ARRANGEMENT REQUEST FORM

All examination centers are equipped to provide access in accordance with the Americans with Disabilities Act (ADA) of 1990. Applicants with disabilities may request special examination arrangements.

Candidates who wish to request special arrangements because of a disability should fax this form and supporting documentation to PSI at (702) 932-2666.

Requirements for special arrangement requests

You are required to submit documentation from the medical authority or learning institution that rendered a diagnosis. Verification must be submitted to PSI on the letterhead stationary of the authority or specialist and include the following:

- Description of the disability and limitations related to testing
- Recommended accommodation/modification
- Name, title and telephone number of the medical authority or specialist
- Original signature of the medical authority or specialist

Date_____

Legal Name: _____

Last Name First Name

Address:_____

Street City,State, Zip Code

Telephone : (_____) _____ - _____ (_____) _____ - _____

Home Work

Email Address:_____

Check any special arrangements you require (requests must concur with documentation submitted):

- ☐ Reader (as accommodation for visual impairment or learning disability)
- ☐ Large-Print written examination
- ☐ Out-of-State Testing Request (this request does not required additional documentation)

  Site requested:_____
- ☐ Extended Time (Additional time requested:_____)
- ☐ Service Animals (other than those required for guidance or mobility assistance due to physical disability):_____
- ☐ Other_____

  _____

- **Complete and fax this form, along with supporting documentation, to (702) 932-2666.**
- **After 4 business days, please call (702) 939-6750 and leave a voice message.**
- **PSI Special Accommodations will call you back to schedule the examination within 48 hours.**

DO NOT SCHEDULE YOUR EXAMINATION UNTIL THIS DOCUMENTATION HAS BEEN RECEIVED AND PROCESSED BY PSI SPECIAL ACCOMMODATIONS.

PSI
3210 E Tropicana
Las Vegas, NV 89121