2013 - 2014

Florida Department of Education
Curriculum Framework

Program Title: **Advanced Water Treatment Technologies**
Program Type: **Career Preparatory**
Career Cluster: **Agriculture, Food and Natural Resources**

	PSAV
Program Number	P150509
CIP Number	0715050606
Grade Level	30, 31
Standard Length	612 hours
Teacher Certification	WSP OPER @7 G TEC CHEM @7 G
CTSO	N/A
SOC Codes (all applicable)	51-8031- Water and Wastewater Treatment Plant and System Operators
Facility Code	263 http://www.fldoe.org/edfacil/sref.asp (State Requirements for Educational Facilities)
Targeted Occupation List	http://www.labormarketinfo.com/wec/TargetOccupationList.htm
Perkins Technical Skill Attainment Inventory	http://www.fldoe.org/workforce/perkins/perkins_resources.asp
Industry Certifications	http://www.fldoe.org/workforce/fcpea/default.asp
Statewide Articulation	http://www.fldoe.org/workforce/dwdframe/artic_frame.asp
Basic Skills Level	Mathematics: 9 Language: 9 Reading: 9

Purpose

This program offers a sequence of courses that provides coherent and rigorous content aligned with challenging academic standards and relevant technical knowledge and skills needed to prepare for further education and careers in the water treatment sector of the Agriculture, Food and Natural Resources career cluster; provides technical skill proficiency, and includes competency-based applied learning that contributes to the academic knowledge, higher-order reasoning and problem-solving skills, work attitudes, general employability skills, technical skills, and occupation-specific skills, and knowledge of all aspects of the water treatment sector of the Agriculture, Food and Natural Resources career cluster.

The content includes but is not limited to an understanding of various feed waters; various water treatment schemes, power generation, pharmaceutical, biotech, semiconductor and other applications; safety and troubleshooting of water treatment systems; piping and instrumentation diagrams; pumps, valves, gauges and meters; the pretreatment technologies required to produce safe drinking water as well as the pretreated water required for advanced technologies; the theory, process and equipment of common membrane water treatment systems; and the initial monitoring and troubleshooting skills required to effectively operate and maintain a membrane water treatment system.

Program Structure

This program is a planned sequence of instruction consisting of two occupational completion points.

When offered at the postsecondary adult career and technical level, this program is comprised of courses which have been assigned course numbers in the SCNS (Statewide Course Numbering System) in accordance with Section 1007.24 (1), F.S. Career and Technical credit shall be awarded to the student on a transcript in accordance with Section 1001.44(3)(b), F.S.

The following table illustrates the program structure:

OCP	Course Number	Course Title	Course Length	SOC Code
A	EVS0355	Membrane Water Treatment Specialist	306 hours	51-8031
B	EVS0357	High Purity Water Treatment Specialist	306 hours	51-8031

Laboratory Activities

Laboratory activities are an integral part of this program. These activities include instruction in the use of safety procedures, tools, equipment, materials, and processes related to these occupations. Equipment and supplies should be provided to enhance hands-on experiences for students.

Special Notes

<u>Cooperative Training – OJT</u>

On-the-job training is appropriate but not required for this program. Whenever offered, the rules, guidelines, and requirements specified in the OJT framework apply.

<u>Essential Skills</u>

Essential skills identified by the Division of Career and Adult Education have been integrated into the standards and benchmarks of this program. These skills represent the general knowledge and skills considered by industry to be essential for success in careers across all career clusters. Students preparing for a career served by this program at any level should be able to demonstrate these skills in the context of this program. A complete list of Essential Skills and links to instructional resources in support of these Essential Skills are published on the CTE Essential Skills page of the FL-DOE website (http://www.fldoe.org/workforce/dwdframe/essential_skills.asp).

Basic Skills

In PSAV programs offered for 450 hours or more, in accordance with Rule 6A-10.040, F.A.C. the minimum basic skills grade levels required for postsecondary adult career and technical students to complete this program are: Mathematics 9, Language 9, and Reading 9. These grade level numbers correspond to a grade equivalent score obtained on a state designated basic skills examination.

Adult students with disabilities, as defined in Section 1004.02(7), Florida Statutes, may be exempted from meeting the Basic Skills requirements (Rule 6A-10.040). Students served in exceptional student education (except gifted) as defined in s. 1003.01(3)(a), F.S., may also be exempted from meeting the Basic Skills requirement. Each school district and Florida College must adopt a policy addressing procedures for exempting eligible students with disabilities from the Basic Skills requirement as permitted in Section 1004.91(3), F.S.

Students who possess a college degree at the Associate of Applied Science level or higher; who have completed or are exempt from the college entry-level examination; or who have passed a state, national, or industry licensure exam are exempt from meeting the Basic Skills requirement (Rule 6A-10.040, F.A.C.) Exemptions from state, national or industry licensure are limited to the certifications listed at http://www.fldoe.org/workforce/dwdframe/rtf/basicskills-License-exempt.rtf

Accommodations

Federal and state legislation requires the provision of accommodations for students with disabilities as identified on the secondary student's IEP or 504 plan or postsecondary student's accommodations' plan to meet individual needs and ensure equal access. Postsecondary students with disabilities must self-identify, present documentation, request accommodations if needed, and develop a plan with their counselor and/or instructors. Accommodations received in postsecondary education may differ from those received in secondary education. Accommodations change the way the student is instructed. Students with disabilities may need accommodations in such areas as instructional methods and materials, assignments and assessments, time demands and schedules, learning environment, assistive technology and special communication systems. Documentation of the accommodations requested and provided should be maintained in a confidential file.

In addition to accommodations, some secondary students with disabilities (students with an Individual Educational Plan (IEP) served in Exceptional Student Education or ESE) will need modifications to meet their needs. Modifications change the outcomes or what the student is expected to learn, e.g., modifying the curriculum of a secondary career and technical education course. Note postsecondary curriculum cannot be modified.

Some secondary students with disabilities (ESE) may need additional time (i.e., longer than the regular school year), to master the student performance standards associated with a regular Occupational Completion Point (OCP) or a Modified Occupational Completion Point (MOCP). If needed, a student may enroll in the same career and technical course more than once. Documentation should be included in the IEP that clearly indicates that it is anticipated that the student may need an additional year to complete an OCP/MOCP. The student should work on different competencies and new applications of competencies each year toward completion of the OCP/MOCP. After achieving the competencies identified for the year, the student earns credit for the course. It is important to ensure that credits earned by students are reported accurately. The district's information system must be designed to accept multiple credits for the same course number (for eligible students with disabilities).

Articulation

This program has no statewide articulation agreement approved by the Florida State Board of Education. However, this does not preclude the awarding of credits by any college through local agreements.

For details on statewide articulation agreements which correlate to programs and industry certifications, refer to http://www.fldoe.org/workforce/dwdframe/artic_frame.asp.

Standards

After successfully completing this program, the student will be able to perform the following:

01.0 Identify jobs related to the advanced water treatment field.
02.0 Identify safety hazards associated with advanced water technologies.
03.0 Explain the importance of each section on a Material Safety Data Sheet (MSDS).
04.0 Solve basic math problems common to advanced water treatment technologies.
05.0 Describe how various pumps work and basic hydraulic principles.
06.0 Identify various valves and the differences in different piping materials.
07.0 Compare and contrast the characteristics of drinking water, boiler feed water, semiconductor rinse water and pharmaceutical water.
08.0 Demonstrate job interviewing skills and resume/cover letter writing skills.
09.0 Describe the different types of contaminants in various feed waters.
10.0 Demonstrate how to use piping & instrumentation diagrams (P & ID) and process flow diagrams (PFD) to understand a water treatment process.
11.0 Describe the theory, equipment, and practice of scaling-control pretreatment technologies.
12.0 Describe the theory, equipment, and practice of fouling-control pretreatment technologies.
13.0 Describe the theory, equipment, and practice of chemical attack-control pretreatment technologies.
14.0 Describe the theory, equipment, and practice of chlorination and chloramination.
15.0 Identify where in a water treatment system various contaminants are removed.
16.0 Explain how reverse osmosis (RO) works.
17.0 Describe the rejection capabilities of each type of membrane.
18.0 Explain how to chemically clean a membrane unit.
19.0 Explain how to monitor before, during, and after chemical cleaning.
20.0 Explain which type, or types, of membrane to use in different water treatment applications.
21.0 Describe the pretreatment requirements for different membrane technologies.
22.0 Explain why conventional water treatment has difficulty removing Cryptosporidium and Giardia cysts and which membrane technologies to use.
23.0 Describe the three most common problems with nanofiltration and RO membranes.
24.0 Describe the instruments and the monitoring required to catch performance problems at an early stage.

25.0 Describe the common methods used to control scaling, fouling and chemical attack in membrane units.
26.0 Explain the differences between designing for well water and designing for surface water.
27.0 Demonstrate how to use advanced troubleshooting techniques.
28.0 Explain the information on a membrane manufacturer's specification sheet and how to practically use this information at a plant.
29.0 Demonstrate how to operate and maintain an RO unit.
30.0 Explain why membrane water treatment is becoming common for the production of municipal drinking water.
31.0 Describe and perform appropriate water analyses.
32.0 Describe and perform appropriate sampling techniques.
33.0 Describe the theory, equipment, and operation of aeration, decarbonation, and degasification.
34.0 Describe the theory, equipment, and operation of stabilizing water.
35.0 Describe the theory, equipment, and operation of corrosion control.
36.0 Describe the characteristics and the measurement of silica contaminants.
37.0 Describe the characteristics and the measurement of organic contaminants.
38.0 Describe the characteristics and the measurement of ionic contaminants.
39.0 Describe the characteristics and the measurement of non-living particle contaminants.
40.0 Describe the characteristics and the measurement of living particle contaminants.
41.0 Explain the monitoring and troubleshooting required for media filters.
42.0 Explain the monitoring and troubleshooting required for activated carbon beds.
43.0 Explain the monitoring and troubleshooting required for membrane units.
44.0 Explain the theory, equipment, and practice of probing.
45.0 Explain the theory, equipment, and practice of profiling.
46.0 Explain the theory, equipment, and practice of membrane element replacement.
47.0 Demonstrate how to chemically clean an RO unit.
48.0 Demonstrate how to use software programs to trend membrane unit performance.
49.0 Demonstrate how to use software programs to check the scaling and fouling characteristics of a membrane unit.
50.0 Explain the theory, and describe the function, of ion exchange resin beads and resin sheets.
51.0 Explain the concept of selectivity.
52.0 Demonstrate an understanding of selectivity.
53.0 Describe the normal operation of strong acid cation (SAC) single-bed ion exchange units.
54.0 Describe and demonstrate how to regenerate an SAC single bed.
55.0 Describe the normal operation of strong base anion (SBA) single-bed ion exchange units.
56.0 Describe and demonstrate how to regenerate an SBA single bed.
57.0 Describe the normal operation of a SAC and SBA dual-bed ion exchange system.
58.0 Describe the normal operation of mixed-bed ion exchange units.
59.0 Describe how to regenerate a mixed bed.
60.0 Describe the normal operation and regeneration of electrodeionization units.
61.0 Describe the normal operation of 254 nm and 185 nm ultraviolet (UV) irradiation units.
62.0 Explain the functions of final filters.
63.0 Explain the usage of ozone in high purity water treatment systems.
64.0 Explain the problems caused by dead legs.
65.0 Identify the pieces of equipment that remove feed water contaminants.

2013 - 2014

Florida Department of Education
Student Performance Standards

Program Title: Advanced Water Treatment Technologies
PSAV Number: P150509

Course Number: EVS0355
Occupational Completion Point: A
Membrane Water Treatment Specialist – 306 Hours – SOC Code 51-8031

01.0 Identify jobs related to the advanced water treatment field--The student will be able to:

01.01 List the duties of various advanced water treatment jobs such as operator, service technician, sales rep, lab technician, instrumentation and control technician, and sales engineer.
01.02 List the personality traits that are beneficial for each job.
01.03 List potential employers in the advanced water treatment field, including semiconductor, power generation drinking water, beverage, pharmaceutical, biotech, and governmental agencies.
01.04 Describe how to contact potential employers through websites.

02.0 Identify safety hazards associated with advanced water technologies--The student will be able to:

02.01 List the tripping hazards in an advanced water treatment plant.
02.02 List the electrocution hazards in an advanced water treatment plant.
02.03 List the chemical hazards in an advanced water treatment plant.
02.04 List the fire hazards in an advanced water treatment plant.
02.05 List the cutting hazards in an advanced water treatment plant.
02.06 List the inhalation hazards in an advanced water treatment plant.

03.0 Explain the importance of each section on a Material Safety Data Sheet (MSDS)--The student will be able to:

03.01 Identify the chemical properties of the chemical.
03.02 Identify the hazards associated with the chemical.
03.03 Identify any fire hazards associated with the chemical.
03.04 Identify any fire fighting procedures recommended.
03.05 Identify the personal protection equipment and procedures required when handling the chemical.
03.06 Identify the toxicological effects of the chemical.

04.0 Solve basic math problems common to advanced water treatment technologies--The student will be able to:

04.01 Calculate Normalized Permeate Flow.
04.02 Calculate Percent Salt Rejection.
04.03 Calculate Differential Pressures.
04.04 Calculate +/- percentages on water analysis reports.
04.05 Calculate Net Driving Pressure.

04.06 Calculate average pressures, salt concentrations, and osmotic pressures.
04.07 Calculate water flux in gallons per square foot of membrane per day.

05.0 Describe how various pumps work and basic hydraulic principles--The student will be able to:

05.01 Describe how a given example of a positive displacement pump works.
05.02 Describe how a given example of a centrifugal pump works.
05.03 Describe the differences between two different types of well pumps.
05.04 List a minimum of three things to check out on an operating pump.
05.05 Define suction head.
05.06 Define discharge head.
05.07 Describe a pump curve.
05.08 Define gauge pressure versus absolute pressure.
05.09 Discuss principles of multi-stage centrifugal pumps.
05.10 Discuss hydraulic principles.

06.0 Identify various valves and the differences in piping materials--The student will be able to:

06.01 Identify a globe valve.
06.02 Identify a ball valve.
06.03 Identify a gate valve.
06.04 Identify a needle valve.
06.05 Identify a butterfly valve.
06.06 Identify a plug valve.
06.07 Identify various actuated control valves.
06.08 Identify PVC piping material.
06.09 Identify carbon steel piping material.
06.10 Identify various stainless steel piping materials.
06.11 Identify PVDF piping material.
06.12 Define gauges of pipe.
06.13 Discuss the support requirements for different pipe materials (i.e. pvdf continuous, PVC short intervals, carbon steel longer intervals, etc.)
06.14 Discuss temperature of conveyed material versus psi rating of pipe.
06.15 Discuss head loss associated with fittings and pipe friction.
06.16 Compare and contrast pipe sizing versus flow rate – target feet per second flow design rates

07.0 Compare and contrast the characteristics of drinking water, boiler feed water, semiconductor rinse water and pharmaceutical water--The student will be able to:

07.01 List the order of end-use water quality from drinking water to semiconductor rinse water.
07.02 List the regulatory agencies and their roles in monitoring drinking water.
07.03 Define state and federal regulations concerning drinking water
07.04 Define the training and certification requirements for drinking water operators.
07.05 List the contaminant limitations of 2000 PSI boiler water.
07.06 List the contaminant limitations of purified water.
07.07 List the contaminant limitations of water for Injection.

07.08 List the contaminant limitations for rinse water used to make 0.18 micron semiconductor devices.

08.0 <u>Demonstrate job interviewing skills and resume/cover letter writing skills</u>--The student will be able to:

08.01 Describe the job search process.
08.02 Explain the most important characteristics of a good cover letter.
08.03 Explain the most important characteristics of a good resume.
08.04 Explain some of the most important considerations during a job interview.
08.05 Explain the employer concerns that the cover letter should address.
08.06 Explain the purpose of a cover letter.
08.07 Explain the purpose of a resume.
08.08 Describe how to dress for an interview.
08.09 Describe how to act at an interview.

09.0 <u>Describe the different types of contaminants in various feed waters</u>--The student will be able to:

09.01 List the different categories of source water.
09.02 Identify the TDS classification of fresh water, brackish water, highly brackish water, and seawater.
09.03 List common characteristics of surface water.
09.04 List common characteristics of well water.
09.05 List common characteristics of seawater.
09.06 Define the six different categories of water contaminants.
09.07 Compare and contrast the ionic, gaseous, siliceous, organic, non-living and living particulate differences between ground water and surface water.

10.0 <u>Demonstrate how to use piping and instrumentation diagrams (P & ID) and process flow diagrams (PFD) to understand a water treatment process</u>--The student will be able to:

10.01 Identify the sequence of the main pieces of equipment at a water treatment plant given a PFD.
10.02 Identify the instruments at a water treatment plant given a P & ID.
10.03 Trace lines using a P & ID.
10.04 Define an indicator, transmitter, and indicating controller.
10.05 Identify flaws in given PFD.

11.0 <u>Describe the theory, equipment, and practice of scaling-control pretreatment technologies</u>--The student will be able to:

11.01 Describe the theory and practice of ion exchange softeners.
11.02 Describe the theory and practice of acid injection.
11.03 Describe the theory and practice of scale inhibitor injection.
11.04 Identify the one scalant that ion exchange softeners cannot handle.
11.05 Describe the limitations of scale inhibitors.
11.06 Describe what acid injection does to calcium carbonate scale potential.
11.07 Describe what acid injection does for non-carbonate scale potential.
11.08 Describe the benefits of adding caustic between two-pass RO's to remove CO_2 in the 1^{st} pass permeate (reduce loading on downstream DI trains).

12.0 Describe the theory, equipment, and practice of fouling-control pretreatment technologies--The student will be able to:

12.01 Describe the theory and practice of clarifiers.
12.02 Describe the theory and practice of multimedia filters.
12.03 Describe the theory and practice of sand filters.
12.04 Describe the theory and practice of green sand filters.
12.05 Describe the theory and practice of bag filters.
12.06 Describe the theory and practice of cartridge filters.
12.07 Describe the theory and practice of coagulant injection.
12.08 Describe the theory and practice of flocculant injection.
12.09 Describe the theory and practice of organic scavengers.
12.10 Describe the theory and practice of silt dispersant injection.
12.11 Compare membrane pretreatment technologies – nanofilters, ultrafilters and microfilters (double or triple membrane systems becoming more popular).

13.0 Describe the theory, equipment, and practice of chemical attack control pretreatment technologies--The student will be able to:

13.01 Describe the theory and practice of activated carbon beds.
13.02 Describe the theory and practice of pH control for cellulosic membranes.
13.03 Describe the theory and practice of sulfite ion injection.
13.04 Describe the theory and practice of ultraviolet irradiation for removal of chlorine and ozone.

14.0 Describe the theory, equipment, and practice of chlorination and chloramination--The student will be able to:

14.01 Describe the chemical reaction of chlorine with water.
14.02 List free chlorine compounds.
14.03 List the chemical reaction of chlorine and ammonia.
14.04 Describe the relationship among free chlorine, combined chlorine, and total chlorine.
14.05 Explain what happens to the proportion of free chlorine compounds with changes in pH.
14.06 Describe at what pH free chlorine is most biocidal.
14.07 Explain the reason for chloramination as opposed to breakpoint free chlorination.
14.08 Explain the difference in the affect of free chlorine and combined chlorine with polyamide thin film membranes.
14.09 Explain the affects of iron, copper, and cobalt in relationship with chlorine attack of polyamide thin film membranes.
14.10 Discuss how chemicals affect CA membranes versus TFC membranes.

15.0 Identify where in a water treatment system various contaminants are removed--The student will be able to:

15.01 Identify, given various water treatment schemes, where ionic contaminants are removed.
15.02 Identify, given various water treatment schemes, where organic contaminants are removed.
15.03 Identify, given various water treatment schemes, where siliceous contaminants are removed.
15.04 Identify, given various water treatment schemes, where gaseous contaminants are removed.
15.05 Identify, given various water treatment schemes, where non-living particulate contaminants are removed.
15.06 Identify, given various water treatment schemes, where living particulate contaminants are removed.

16.0 Explain how reverse osmosis works--The student will be able to:

16.01 Explain the process of osmosis.
16.02 Define a semipermeable membrane.
16.03 Explain the concept of applied pressure.
16.04 Explain the concept of osmotic pressure.
16.05 Explain the concept of net osmotic pressure.
16.06 Explain the process of reverse osmosis.
16.07 Explain the relationship of net driving pressure to water flux through a membrane.
16.08 Describe how a membrane element works.

17.0 Describe the rejection capabilities of each type of membrane--The student will be able to:

17.01 Describe how nanofiltration and reverse osmosis membrane reject ionic contaminants.
17.02 Describe how nanofiltration and reverse osmosis membrane reject non-ionic contaminants.
17.03 Describe the rejection capabilities of microfiltration membranes.
17.04 Describe the rejection capabilities of ultrafiltration membranes.
17.05 Describe the rejection capabilities of nanofiltration membranes.
17.06 Describe the rejection capabilities of hyperfiltration membranes.

18.0 Explain how to chemically clean a membrane unit--The student will be able to:

18.01 Describe the symptoms of a fouled membrane unit.
18.02 Describe the symptoms of a scaled membrane unit.
18.03 Describe the game plan required to remove scalants.
18.04 Describe the game plan required to remove foulants.
18.05 List generic chemicals used to remove scalants.
18.06 List generic chemicals used to remove foulants.
18.07 Describe air scouring during membrane CIP.
18.08 Discuss CIP versus removal for offsite cleaning and why offsite may be more beneficial under certain fouling circumstances.

19.0 Explain how to monitor before, during, and after chemical cleaning--The student will be able to:

19.01 Identify membrane unit performance trends that indicate the need for cleaning.
19.02 List a minimum of six parameters that should be monitored during a chemical cleaning.
19.03 Explain the problems that cleaning at too high or low a pH may cause.
19.04 Explain the problems that cleaning at too high or low a temperature may cause.
19.05 Explain the problems that cleaning at too high or low a flow rate may cause.
19.06 Describe the data used to indicate when to end a cleaning.
19.07 Describe the monitoring parameters that document how well a cleaning was performed.

20.0 Explain which type, or types, of membrane to use in different water treatment applications--The student will be able to:

20.01 Identify, given a feed water analysis and end-use requirements, whether microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and/or reverse osmosis (RO) would produce the desired end-use water.
20.02 Describe the most important parameters for determining which membrane technology to use.
20.03 Define the pore size of MF membranes and provide examples for both municipal and industrial applications.
20.04 Define the pore size of UF membranes and provide examples for both municipal and industrial applications.
20.05 Define the pore size of NF membranes and provide examples for both municipal and industrial applications.
20.06 Define the pore size of RO membranes and provide examples for both municipal and industrial applications.

21.0 Describe the pretreatment requirements for different membrane technologies--The student will be able to:

21.01 Describe the pretreatment requirements for MF.
21.02 Describe the pretreatment requirements for UF.
21.03 Describe the pretreatment requirements for NF and RO to control scaling.
21.04 Describe the pretreatment requirements for NF and RO to control colloidal fouling.
21.05 Describe the pretreatment requirements for NF and RO to control biofouling.
21.06 Describe the pretreatment requirements for NF and RO to control chemical attack.

22.0 Explain why conventional water treatment has difficulty removing Cryptosporidium and Giardia cysts and which membrane technologies are effective--The student will be able to:

22.01 Define the size of Cryptosporidium and Giardia cysts.
22.02 Define the removal capabilities of coagulation, flocculation, sedimentation, and media filtration.
22.03 Explain why chlorination is not effective enough for inactivation of Cryptosporidium and Giardia cysts.

22.04 Identify which membrane technologies will effectively remove both Cryptosporidium and Giardia cysts.

23.0 Describe the three most common problems with nanofiltration and reverse osmosis membranes--The student will be able to:

23.01 Describe the mechanisms of scaling in NF and RO units.
23.02 Describe the mechanisms of fouling in NF and RO units.
23.03 Describe the mechanisms of chemical attack of NF and RO membranes.
23.04 Explain why NF membrane units may foul more than RO units.
23.05 Describe design features that reduce the fouling of NF and RO units.
23.06 Explain where fouling is the worst in NF and RO units.

24.0 Describe the instruments and the monitoring required to catch NF and RO problems at an early stage--The student will be able to:

24.01 List the minimum instrumentation required for effective monitoring.
24.02 Explain why interstage pressure gauges are required.
24.03 Explain the need for a feed water temperature indicator.
24.04 Explain the need for a permeate pressure gauge.
24.05 Demonstrate the ability to collect performance data and input it into the appropriate membrane manufacturer’s monitoring software programs.
24.06 Demonstrate the ability to produce normalized permeate flow, percent salt rejection, and pressure drop performance trends.
24.07 List the instruments required to calculate net driving pressure.
24.08 List the instruments required to calculate normalized permeate flow.
24.09 List the instruments required to calculate percent salt passage.
24.10 List the instruments required to calculate percent recovery.
24.11 List the instruments required to calculate pressure drops.
24.12 Calculate net driving pressure given performance data from a membrane unit.
24.13 Calculate normalized permeate flow given performance data from a membrane unit.
24.14 Calculate percent salt rejection given performance data from a membrane unit.
24.15 Calculate percent recovery given performance data from a membrane unit.
24.16 Calculate pressure drops given performance data from a membrane unit.

25.0 Describe the common methods used to control scaling, fouling, and chemical attack in RO & NF units--The student will be able to:

25.01 List a minimum of six treatment steps or design features used to control scaling.
25.02 List a minimum of eight treatment steps or design features used to control colloidal fouling.
25.03 List a minimum of six treatment steps or design features used to control biofouling.
25.04 List a minimum of three treatment steps used to control chemical attack.

26.0 Explain the differences between designing membrane units for well water and designing for surface water--The student will be able to:

26.01 Explain the concept of GFD (gallons per square foot per day) based on different source waters.

26.02 Explain why well water will typically require less membrane than surface water.
26.03 Describe the common characteristics of shallow well water.
26.04 Describe the common characteristics of deep well water.
26.05 Describe the common characteristics of surface water.
26.06 Describe the common characteristics of seawater.
26.07 Draw three typical treatment schemes for RO and NF units operating on well water.
26.08 Draw three typical treatment schemes for RO and NF units operating on surface water.

27.0 <u>Demonstrate how to use advanced troubleshooting techniques</u>--The student will be able to:

27.01 Identify scaling given normalized permeate flow, percent salt rejection, and pressure drop performance graphs.
27.02 Identify fouling given normalized permeate flow, percent salt rejection, and pressure drop performance graphs.
27.03 Identify chemical attack given normalized permeate flow, percent salt rejection, and pressure drop performance graphs.
27.04 Determine a calcium carbonate scaling problem using membrane manufacturer's design software.
27.05 Determine a calcium sulfate scaling problem using membrane manufacturer's design software.
27.06 Determine a barium sulfate scaling problem using membrane manufacturer's design software.
27.07 Determine a strontium sulfate scaling problem using membrane manufacturer's design software.
27.08 Determine a silica scaling problem using membrane manufacturer's design software.
27.09 Determine that a unit is fouling due to high GFD.
27.10 Determine that a unit is fouling due to low cross flow velocities.

28.0 <u>Explain the information on a membrane manufacturer's specification sheet and how to practically use this information at a plant</u>--The student will be able to:

28.01 Identify the square footage of membrane per element and explain the significance.
28.02 Identify the test conditions of the membrane elements and explain the significance.
28.03 Identify the allowable normal operating and chemical cleaning temperature ranges of the membrane elements and explain the significance.
28.04 Identify the allowable normal operating and chemical cleaning pH ranges of the membrane elements and explain the significance.
28.05 Identify whether membrane elements are fiberglass wrapped or cage wrapped and explain the significance.
28.06 Identify heat sanitizable membrane elements and explain why and when these elements would be used.
28.07 Identify the pressure drop limitations of membrane elements and explain the significance.
28.08 Describe a minimum of three potentials problems that could occur when switching membrane elements.

29.0 <u>Demonstrate how to operate and maintain an RO unit</u>--The student will be able to:

29.01 Load and unload membrane elements.
29.02 Replace o-rings.
29.03 Replace brine seals.
29.04 Shim a unit.
29.05 Install end-cap adaptors.
29.06 Install interconnectors.
29.07 Replace cartridge filters.
29.08 Dechlorinate the feed water.
29.09 Adjust the pH of the feed water if required.
29.10 Start and stop a unit.
29.11 Adjust the percent recovery by changing the valving.
29.12 Identify an o-ring leak.
29.13 Take conductivity readings.
29.14 Perform the Silt Density Index.
29.15 Profile the unit.
29.16 Perform a probing of a pressure vessel.
29.17 Identify all components of a unit.
29.18 Identify all instruments on a unit.

30.0 <u>Explain why membrane water treatment is becoming common for the production of municipal drinking water</u>--The student will be able to:

30.01 Describe the hydrological cycle.
30.02 Describe the effect the human population increase has on water quality.
30.03 Describe the problem of Cryptosporidium and Giardia cysts.
30.04 Describe the problem with arsenic.
30.05 Describe the problem with disinfection by-products.
30.06 Describe the basic reasons why conventional water treatment cannot remove certain substances down to current and future regulated levels.
30.07 Describe which problems MF can control.
30.08 Describe which problems UF can control.
30.09 Describe which problems NF can control.
30.10 Describe which problems RO can control.

31.0 <u>Describe and perform appropriate water analyses</u>--The student will be able to:

31.01 Identify the laboratory tests required for drinking water, boiler feed water, purified water, water for injection and semiconductor rinse water.
31.02 Identify the bacteriological monitoring that must be done for drinking water, boiler feed water, purified water, water for injection and semiconductor rinse water.
31.03 Describe how the heterotrophic plate count (HPC) enumerates bacteria.
31.04 Describe how sulfate-reducing bacteria (SRB), iron-related bacteria (IRB), and slime-forming bacteria (SFB) are enumerated.
31.05 Perform HPC, SRB, IRB, and SFB bacterial analysis.

32.0 <u>Describe and perform appropriate sampling techniques</u>--The student will be able to:

32.01 Define good sampling techniques for microbiological analysis.
32.02 Perform good sampling techniques for microbiological analysis.
32.03 Define good sampling techniques for chemical analysis.
32.04 Perform good sampling techniques for chemical analysis.

33.0 Describe the theory, equipment, and operation of aeration, decarbonation, and degasification--The student will be able to:

33.01 Describe the theory, equipment, and operation of induced draft aeration/decarbonation.
33.02 Describe the theory, equipment, and operation of forced draft aeration/decarbonation.

34.0 Describe the theory, equipment, and operation of stabilizing water--The student will be able to:

34.01 List the chemicals used to stabilize drinking water.
34.02 Describe how to measure the stability of drinking water.
34.03 Calculate Langelier Saturation Index (LSI) using software programs.

35.0 Describe the theory, equipment, and operation of corrosion control--The student will be able to:

35.01 Describe the process of corrosion.
35.02 Describe the problems caused by corrosion for drinking water, boiler feed water, purified water, water for injection and semiconductor rinse water.
35.03 Identify chemicals used for corrosion control.
35.04 Describe cathodic protection.

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36.0 Describe the characteristics and the measurement of silica contaminants--The student will be able to:

36.01 Describe a problem that silica compounds pose for the power generation, semiconductor, and pharmaceutical industries.
36.02 Describe a problem that silica compounds pose in ion exchange resin.
36.03 Describe a problem that silica compounds pose in nanofiltration and RO units.
36.04 Identify ionic and non-ionic forms of silica compounds.
36.05 Discuss the difference between *reactive* and *non-reactive* silica compounds.
36.06 Discuss the characteristics of colloidal silica compounds.
36.07 Describe how silica compounds are typically measured in a water sample.

37.0 Describe the characteristics and the measurement of organic contaminants--The student will be able to:

37.01 Describe a problem that organic compounds pose for the drinking water, power generation, semiconductor, and pharmaceutical industries.
37.02 Describe a problem that organic compounds pose in ion exchange resin.
37.03 Describe a problem that organic compounds pose in nanofiltration and RO units.
37.04 Describe a problem that organic compounds pose in activated carbon beds.
37.05 Identify ionic and non-ionic forms of organic compounds.
37.06 Discuss the difference between *polar* and *non-polar* organic compounds.
37.07 Discuss the characteristics of colloidal organic compounds.
37.08 Describe how organic compounds are typically measured in a water sample.

38.0 Describe the characteristics and the measurement of ionic contaminants--The student will be able to:

38.01 List six common cations.
38.02 List six common anions.
38.03 List four scaling cations.
38.04 List two scaling anions.
38.05 Discuss the acid ion.
38.06 Discuss the caustic ion.
38.07 List two non-scaling cations.
38.08 List two non-scaling anions.
38.09 Discuss the relationship of pH to ionic carbon dioxide compounds.
38.10 Describe two instruments used to measure ionic contaminants.

39.0 Describe the characteristics and the measurement of non-living particle contaminants--The student will be able to:

39.01 Discuss the importance of the surface charge of colloidal particles.
39.02 Define silt, clay, and sand based upon size and chemical composition.
39.03 Discuss ultraviolet irradiation effectiveness versus suspended solids loading.
39.04 Discuss chemical disinfection effectiveness versus suspended solids loading.
39.05 Discuss the fouling implications to membrane units of suspended solids loading.

39.06 Discuss Silt Density Index measurement of suspended solids.
39.07 Describe how a turbidimeter works.
39.08 Describe how a laser particle counter works.
39.09 Explain how a TSS (Total Suspended Solids) measurement is made.

40.0 Describe the characteristics and the measurement of living particle contaminants--The student will be able to:

40.01 List five types of microbiological particles.
40.02 Describe five ideal conditions for bacterial growth.
40.03 Calculate the number of bacteria present after 24 hours if a bacterium begins reproducing at time zero every 20 minutes.
40.04 List five waterborne diseases.
40.05 Discuss the significance of gram staining.
40.06 Describe the problem that certain gram-negative bacteria produce in the pharmaceutical/biotech industries.
40.07 Describe how a heterotrophic bacterial count is performed.
40.08 Discuss the significance of serial dilution.

41.0 Explain the monitoring and troubleshooting required for media filters--The student will be able to:

41.01 Discuss the significance of pressure drop across a media bed.
41.02 Describe the concept of channeling.
41.03 Explain how a media filter is backwashed.
41.04 Describe how a media bed should look when examined after backwash.
41.05 Discuss the problems that can cause an uneven bed.
41.06 Describe how to sample the media in a bed.
41.07 Explain the implications of water temperature and backwashing.
41.08 Discuss the addition of filter aid polymer to MMF to reduce SDI.
41.09 Discuss the addition of filter aid precoat and/or body feed (using DE) to reduce SDI.

42.0 Explain the monitoring and troubleshooting required for activated carbon beds--The student will be able to:

42.01 Discuss the significance of pressure drop across an activated carbon (AC) bed.
42.02 Discuss the problems associated with channeling and/or exhaustion.
42.03 Identify how to determine if an AC bed is exhausted.
42.04 Explain the bacterial problems associated with AC beds.
42.05 Explain how to sanitize an AC bed.
42.06 Describe the limitations of sanitization of AC beds.
42.07 Discuss the annual monitoring that must be done on AC beds.

43.0 Explain the monitoring and troubleshooting required for membrane units--The student will be able to:

43.01 List the instruments that must be present in order to monitor normalized permeate flow, percent salt rejection, percent recovery, trans-membrane pressure, and differential pressures.

43.02 Identify, given performance graphs, the status of various membrane units.
43.03 Identify, given instrument readings, the status of various membrane units.
43.04 Describe how to test the accuracy of pressure gauges.
43.05 Describe how to test the accuracy of conductivity meters.
43.06 Describe how to test the accuracy of flow meters.
43.07 Demonstrate how to use software programs as troubleshooting tools.

44.0 Explain the theory, equipment, and practice of probing--The student will be able to:

44.01 Describe the purpose of probing.
44.02 Explain when to perform a probing.
44.03 Explain the probing procedure.
44.04 Perform a probing.
44.05 Identify problems, given probing data.
44.06 Demonstrate how to use software programs to supplement probing data.

45.0 Explain the theory, equipment, and practice of profiling--The student will be able to:

45.01 Describe the purpose of profiling.
45.02 Explain when to perform a profiling.
45.03 Explain the profiling procedure.
45.04 Perform a profile.
45.05 Identify problems, given profiling data.
45.06 Demonstrate how to use software programs to supplement profiling data.

46.0 Explain the theory, equipment, and practice of membrane element replacement--The student will be able to:

46.01 Identify elements that need to be replaced given probing and profiling data.
46.02 Identify elements that need to be replaced based on autopsy data.
46.03 Explain how to remove variously located membrane elements from pressure vessels.
46.04 Explain how to install new elements to replace variously located membrane elements in pressure vessels.
46.05 Describe the problems that may occur when installing new elements in pressure vessels that contain used elements.
46.06 Discuss the issues concerning replacing the lead elements.
46.07 Discuss the issues concerning replacing the last elements.
46.08 Identify various lubrication methods that may be employed during membrane element loading and the pros and cons of each method.
46.09 Perform membrane element replacements.

47.0 Demonstrate how to chemically clean an RO unit--The student will be able to:

47.01 List two performance trends that indicate a cleaning is required.
47.02 Explain how fouling and scaling can be distinguished prior to cleaning.
47.03 Explain the chemical cleaning procedure.
47.04 Perform chemical cleanings.
47.05 Identify and correct problems during a cleaning.
47.06 Explain what chemicals to use for different scalants and foulants.

48.0 Demonstrate how to use software programs to trend membrane unit performance--The student will be able to:

48.01 Describe how to download free software from the Internet.
48.02 Demonstrate how to input the data from a complete water analysis.
48.03 Explain how frequently performance data should be recorded and how often the data should be graphed and evaluated.
48.04 Input operating data into the software program.
48.05 Generate graphs using the software program.
48.06 Evaluate performance graphs.

49.0 Demonstrate how to use software programs to check the scaling and fouling characteristics of a membrane unit--The student will be able to:

49.01 Explain how design software can provide scaling and fouling characteristics of a membrane unit.
49.02 Input appropriate data into membrane manufacturer's design software.
49.03 Explain the important information generated by the design software with respect to scaling and fouling.
49.04 Identify, given examples, poor membrane unit designs with respect to scaling and fouling control.
49.05 Explain changes to a poor design that would result in better fouling and scaling control.

50.0 Explain the theory and describe the function of ion exchange resin beads and resin sheets--The student will be able to:

50.01 Describe how ions diffuse into resin beads and resin sheets.
50.02 Describe how charged functional groups within ion exchange resin attract and bond with feed water ions.
50.03 Identify the functional group that makes a strong acid cation resin.
50.04 Identify the functional groups that make a strong base anion resin.
50.05 Explain the importance of resin cross linkage.

51.0 Explain the concept of selectivity--The student will be able to:

51.01 Explain the charge-for-charge ion exchange process.
51.02 List the selectivity order for the hydrogen, calcium, and magnesium ions concerning strong acid cation resin.
51.03 List the selectivity order for hydroxide, silica, bicarbonate, chloride, and sulfate ions concerning strong base anion resin.

52.0 Demonstrate an understanding of selectivity--The student will be able to:

52.01 Identify, given a list of ions, which ions can “kick off” which other ions from strong acid cation resin.
52.02 Identify, given a list of ions, which ions can “kick off” which other ions from strong base anion resin.

53.0 Describe the normal operation of strong acid cation (SAC) single-bed ion exchange units--The student will be able to:

53.01 Identify, given an illustration of a cutaway ion exchange single bed, the valves that must be open and closed, and the flow path through the vessel during normal operation.

53.02 Describe, step-by-step, what happens in an SAC resin bed concerning the migration of ions.
53.03 Identify which ion is the first to break through an SAC bed.
53.04 Identify, given a typical feed water, what the conductivity and pH of an SAC effluent will be compared to the influent.
53.05 Identify, given a non-typical feed water, what the conductivity and pH of an SAC effluent will be compared to the influent.
53.06 Explain the process of “sodium leakage”.

54.0 <u>Describe and demonstrate how to regenerate a SAC single bed</u>--The student will be able to:

54.01 List the most common chemical used to regenerate SAC beds and why it is most common.
54.02 List the second most common chemical used to regenerate SAC beds and which industries typically use this chemical.
54.03 Describe, given an illustration of a cutaway resin bed, what happens during each step of an SAC regeneration.
54.04 Explain the purpose of each of the four steps in an SAC bed regeneration.
54.05 Explain what to monitor during each of the steps in an SAC bed regeneration.
54.06 Identify the performance outcome if the backwash step is too short.
54.07 Identify the performance outcome if the backwash flow rate is too low.
54.08 Identify the performance outcome if the backwash flow rate is too high.
54.09 Identify the performance outcome if the acid injection step is too short.
54.10 Identify the performance outcome if the acid injection step is too long.
54.11 Identify the performance outcome if the rinse step is too short.
54.12 Identify the performance outcome if the rinse step is too long.
54.13 Explain the differences and different outcomes of co-current regeneration versus counter current regeneration.
54.14 Perform a co-current regeneration of a laboratory size SAC bed.

55.0 <u>Describe the normal operation of strong base anion (SBA) single-bed ion exchange units</u>--The student will be able to:

55.01 Identify, given an illustration of a cutaway ion exchange single bed, the valves that must be open and closed, and the flow path through the vessel during normal operation.
55.02 Describe, step-by-step, what happens in an SBA resin bed concerning the migration of ions.
55.03 Identify which ion is the first to break through an SBA bed.
55.04 Identify, given a typical feed water, what the conductivity and pH of an SBA effluent will be compared to the influent.
55.05 Identify, given a non-typical feed water, what the conductivity and pH of an SBA effluent will be compared to the influent.
55.06 Identify, given an illustration of a cutaway SBA unit, where silica, hydroxide, chloride, sulfate, and bicarbonate ions will be located just prior to a regeneration.
55.07 Identify, given an illustration of a cutaway SBA unit, where silica, hydroxide, chloride, sulfate, and bicarbonate ions will be located just after a regeneration.

56.0 Describe and demonstrate how to regenerate an sba single bed--The student will be able to:

56.01 List the most common chemical used to regenerate SBA beds.
56.02 Describe, given an illustration of a cutaway resin bed, what happens during each step of an SBA regeneration.
56.03 Explain the purpose of each of the four steps in an SBA bed regeneration.
56.04 Explain what to monitor during each of the steps in an SBA bed regeneration.
56.05 Identify the performance outcome if the backwash step is too short.
56.06 Identify the performance outcome if the backwash flow rate is too low.
56.07 Identify the performance outcome if the backwash flow rate is too high.
56.08 Identify the performance outcome if the caustic injection step is too short.
56.09 Identify the performance outcome if the caustic injection step is too long.
56.10 Identify the performance outcome if the rinse step is too short.
56.11 Identify the performance outcome if the rinse step is too long.
56.12 Explain the differences and different outcomes of co-current regeneration versus counter current regeneration.
56.13 Perform a co-current regeneration of a laboratory size SBA bed.

57.0 Describe the normal operation of a SAC and SBA dual-bed ion exchange system--The student will be able to:

57.01 Explain, step-by-step, what happens to hydrogen, sodium, calcium, magnesium, silica, hydroxide, bicarbonate, chloride, and sulfate ions in a dual-bed system.
57.02 Explain the impact of increased sodium leakage.
57.03 Describe how to determine if the SAC bed exhausts first.
57.04 Describe how to determine if the SBA bed exhausts first.
57.05 Identify the relative pH and conductivity of the influents and effluents of each bed given a particular feed water.
57.06 Describe what happens to the concentration of SBA effluent silica with SAC bed break through.

58.0 Describe the normal operation of mixed-bed ion exchange units--The student will be able to:

58.01 Explain the concept of a polishing mixed bed.
58.02 List the types of resin in a mixed bed and how they are configured.
58.03 Explain, step-by-step, given a cutaway illustration of a mixed bed vessel, how the unit works.
58.04 Identify which ion is the first to break through a mixed bed.
58.05 Identify how to determine which resin is exhausted.
58.06 Describe the correlation between conductivity and resistivity.
58.07 Explain the instrumentation required on a mixed bed effluent if ultra-pure water is required.

59.0 Describe how to regenerate a mixed bed--The student will be able to:

59.01 Identify the ten steps of a mixed-bed regeneration.
59.02 Identify, given an illustration of a cutaway mixed-bed vessel, the flow path during each step of a mixed-bed regeneration.
59.03 Describe what happens to the different resins during the backwash step.

59.04 Explain the function of “inert resin”.
59.05 Identify how to tell if a good backwash has occurred.
59.06 Identify the problems associated with a poor backwash.
59.07 Explain the consequences of the resin separation line being too high or too low.
59.08 Describe the flow path of acid and caustic during the regenerant injection step.
59.09 Identify the problems associated with too high or too low regenerant flow rates.
59.10 Explain the reason why hot caustic is frequently used for a mixed-bed regeneration.
59.11 Explain the purpose of the regenerant displacement step.
59.12 Explain the purpose of the air mix step.
59.13 Identify the problems that may occur if the air mix step is not effective.
59.14 Describe “bed lock” and how it is accomplished.
59.15 Describe the difference between the slow rinse step and the fast rinse step.

60.0 <u>Describe the normal operation and regeneration of an electrode ionization unit</u>--The student will be able to:

60.01 Identify, given an illustration of an electrodeionization (EDI) unit, the anion transfer resin sheets, cation transfer resin sheets, mixed resin beads, dilute channels, concentrate channels, recirculation pump, waste line, and electrodes.
60.02 Explain how an EDI unit works during normal operation.
60.03 Explain how an EDI unit is regenerated continuously.
60.04 Describe the pretreatment requirements for most EDI units.

61.0 <u>Describe the normal operation of 254 nm and 185 nm ultraviolet (UV) irradiation units</u>--The student will be able to:

61.01 Describe at least three differences between low pressure and medium pressure UV systems.
61.02 Describe at least three uses for 254 nm UV units.
61.03 Describe the main reason for using 185 nm UV units for high purity water applications.
61.04 Describe the difference between 254 nm and 185 nm UV lamps.
61.05 Explain the purpose of a quartz sleeve in a low pressure UV system.
61.06 Explain “solarization”.
61.07 Describe how a 185 nm UV irradiation destroys organic compounds.
61.08 Explain what happens to the conductivity or resistivity of the effluent of 254 nm and 185 nm UV units compared to the influent.
61.09 Identify the useful life of low pressure and medium pressure UV lamps.
61.10 Explain why UV units have stainless steel inlets and outlets even if connected to plastic pipe.
61.11 Explain why there is always a polishing mixed bed downstream of a 185 nm UV unit in a high purity water treatment system.
61.12 Explain why there is usually a filter downstream of a germicidal UV unit.

62.0 <u>Explain the functions of final filters</u>--The student will be able to:

62.01 Explain the purpose of final filters in a high purity water treatment system.
62.02 List at least three different types of final filter used.
62.03 Describe at least two different ways to test the integrity of final filters.

63.0 Explain the usage of ozone in high purity water treatment systems--The student will be able to:

63.01 Identify two potential points in a high purity water loop where ozone may be continuously injected.
63.02 Describe at least two reasons for injecting ozone.

64.0 Explain the problems caused by dead legs--The student will be able to:

64.01 Define a “dead leg”.
64.02 Describe the two main problems caused by dead legs.

65.0 Identify the pieces of equipment that remove feed water contaminants--The student will be able to:

65.01 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of particles greater than 20 microns.
65.02 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of particles greater than 1 micron.
65.03 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of particles greater than 0.1 micron.
65.04 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of particles greater than 0.01 micron.
65.05 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of calcium ions.
65.06 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of colloidal silica.
65.07 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of colloidal organic particles.
65.08 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of dissolved organic compounds.
65.09 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of dissolved ionic silica compounds.
65.10 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of chlorine compounds ahead of an RO unit.
65.11 Identify, given a high purity water treatment scheme, which pieces of equipment will reduce the concentration of scaling compounds ahead of an RO unit.
65.12 Identify, given a high purity water treatment scheme, which pieces of equipment will be most prone to biofouling.
65.13 Identify, given a high purity water treatment scheme, which pieces of equipment will be most prone to scaling.
65.14 Identify, given a high purity water treatment scheme, which pieces of equipment will be most prone to chemical attack.