DW Module 17:
Slow Sand Filtration
Answer Key

Calculate the area required for a slow sand filter if it is to serve a population of 1,500 and pilot testing has indicated that the filter should be operated at a flow rate of 0.04 gpm/sq. ft. Use a projected use of 100 gpd per person and assume that there will be no industrial or commercial users.

Ans: Population: 1,500 * 100 gpd/person = 150,000 gpd requirement

150,000 gpd / 1,440 minutes/day = 104 gpm

104 gpm / 0.04 gpm/sq. ft. = 2,604 sq. ft.

Two filters of at least 2,604 sq. ft. will need to be constructed.

Exercise

Unit 1 – Exercise

1. Which of the following are filtration techniques? (*Choose all that apply*)

   a. rapid sand
   b. pressure
   c. mechanical
   d. chlorination
   e. slow sand

(Answer: a., b., c., and e.)

Fill in the blank:

2. Label the following as "R" for rapid sand filter and "S" for slow sand filter.

R flow rates of 2 gpm/sq. ft. or higher
S during cleaning, the top layer of the schmutzdecke is scraped from the top of the filter
R uses backwashing to clean the media (water flow is reversed through the filter and the backwash waste water is removed from the filter)
R mechanical components consist of filter box, underdrain, surface agitator, and filter media
S mechanical components consist of filter box, underdrain, and filter media
S low rates of 0.04 to 0.08 gpm/ sq. ft. are common

True or False: Label the following statements as "T" for True or "F" for false:

3. _T_____ Pressure filtration is typically used on ground water to accomplish iron and manganese r removal or softening.

4. _F_____ Slow sand filtration is a good choice for poorer quality surface waters

5. _F_____ The first documented use of a slow sand filter was in England in 1492.

6. _T_____ n pressure filtration, a pump or other mechanism pushes the water through the filter.

7. _T_____ The chemical use in slow sand filtration plants is much lower than in conventional filtration plants because biological filtration is used..

8. _T_____ Rapid sand filters may be preceded by the treatment processes of coagulation, flocculation, and sedimentation.

9. _F_____ Slow sand filters need to be backwashed on a periodic basis.

Fill in the blank:

10. Label the following as “M” for mechanical filtration, “R” for rapid sand filtration, and “S” for slow sand filtration.

_S_____ training, sedimentation, and adsorption are enhanced by the schmutzdecke

_M____ examples are bag and cartridge filters
_R____ typical example of filter media includes sand, sometimes a “cap” of granulated activated carbon, and sometimes a thin layer of garnet sand
_M____ media is usually made from a fabric or polymeric substance
_R____ the most common type of filtration used in water treatment
_M____ undergo periodic reverse flow chemical cleaning; whole filter is replaced when terminal head loss is reached
_S_____ filter-to-waste cycle can last days or even weeks

Exercise

Unit 2 – Exercise

Multiple Choice – Choose the best answer unless otherwise noted:

1. Which of the following is not a requirement to consider when determining the feasibility of constructing a slow sand filter?

f. cover for the filter
g. location of the closest sand manufacturer
h. enough available space
i. site with good access
j. ability to discharge overflow water

(Answer: b. location of the closest sand manufacturer)

2. Which of the following are pretreatment modifications that can be used to improve a source water quality to make it suitable for slow sand filtration? (*Choose all that apply*)

a. roughing filters
b. presedimentation basins
c. sand washing
d. nutrient addition for schmutzdecke formation

(Answers: a., b., and d.)

3. Which of the following is not a monitoring device on a slow sand filter?

a. sight tube
b. turbidimeter
c. air binding tube
d. flow meter
e. loss of head gauge
f. chlorine analyzer

(Answer: c. air binding tube)

4. The sand in a slow sand filter is composed almost exclusively of _____.

a. calcium
b. mica
c. silica

(Answer: c. silica)

5. A slow sand treatment storage facility should provide at least _____ hours of reserve capacity

a. 12
b. 10
c. 8

(Answer: a. – 12 hours)

6. A slow sand filter does not undergo _____ .

a. backwashing

b. draining for maintenance
c. cleaning

(Answer: a. – backwashing)

Matching – Match the slow sand filter parts with the corresponding description:

_*4*___ A. Underdrain	1. Controls flow rate through the filter
_*1*___ B. Rate of flow controller	2. Consists of support gravel and filter sand
_*5*___ C. Filter Effluent Turbidimeter	3. Helps the operator determine when a filter needs cleaned – monitors head loss
_*3*___ D. Head loss gauge	4. Collects the filtrate
_*2*___ E. Slow Sand Filter Media	5. Single most important piece of monitoring equipment to verify proper filter operation

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Exercise: Calculate the loading rate on a slow sand filter if its dimensions are 20 ft. long by 40 ft. wide and it treats 35 gpm.

Ans: First calculate the filter's surface area: 20 ft. X 40 ft. = 800 sq. ft.

Next divide the flow rate by the filter's surface area: 35 gpm / 880 sq. ft. = 0.044 gpm / sq. ft.

Exercise

Unit 3 – Exercise

Multiple Choice – Choose the best answer unless otherwise noted:

1. What are the two different operational modes for a slow sand filter? (*Choose two*)

a. influent flow control
b. performance flow control
c. effluent flow control
d. loading flow control

(Answer: a. influent flow control + c. effluent flow control)

2. Which is the most commonly used and perhaps the most effective method of cleaning a slow sand filter?

a. scraping
b. raking
c. wet harrowing

(Answer: a.-scraping)

3. Water systems that filter must report turbidity results to the state within how many days after the end of each month?

a. 3
b. 5
c. 7
d. 10

(Answer: d. - 10)

3 Which is the cleaning method that uses water to move the raked windrows to a drain or weir?

a. scraping
b. raking
c. wet harrowing

(Answer: c. – wet harrowing)

4. Which is the cleaning procedure used to increase the filter's run time without removing a layer of the schmuzdecke?

a. scraping
b. raking
c. wet harrowing

(Answer: b. - raking)

5. Which is the best flow pattern for slow sand filter performance?

a. constant
b. variable
c. intermittant

(Answer: a. - constant)

6. After cleaning, the schmutzdecke of a slow sand filter needs to ripen and mature by running the filter in "filter-to-waste" mode. A filter is considered mature when coliform counts are less than 1 cfu per 100 ml and the effluent has a turbidity below which of the following?

a. 0.01 NTU
b. 0.1 NTU
c. 1 NTU

(Answer: b. 0.1 NTU)

7. Select the cyclic influences that may impact the operation of a slow sand filter? (*Choose all that apply*)

a. heavy downpours

b. diurnal fluctuations
c. changes in source water temperature
d. changes in the amount of solar radiation the filter is exposed to

(Answer: a., b., c., and d.)

8. In a slow sand filter a high percentage of Giardia cysts are removed by:

a. biological processes
b. chemical disinfection
c. changes in source water temperature
d. changes in the amount of solar radiation the filter is exposed to

(Answer: a., b., c., and d.)

9. Select the description of the unfiltered water which will result in shorter filter run times.

a. disinfected before being filtered
b. contains more than 15 units of color
c. is clear and cold
d. is undergoing an algae bloom

(Answer: d.- is undergoing an algae bloom)

10. According to the PA DEP Surface Water Treatment Rule, the maximum allowable turbidity that can be produced by a slow sand filter is that the combined filter effluent turbidity must be less than or equal to _____ NTU in at least 95% of the measurements taken each month.

a. 0.3 NTU
b. 0.5 NTU
c. 1.0 NTU
d. 0.1 NTU

(Answer: c. 1 NTU)

Calculation – Follow the directions to perform the calculation and select the best answer to fill in the blank:

The Tinytown slow sand filter is 30 ft. long by 50 ft. wide and treats 35 gpm, we use the following calculation to calculate Tinytown's loading rate:

Flow rate ÷ (filter length x filter width) = filter loading rate
35 gpm ÷ (30 ft. x 50 ft.) = Tinytown's loading rate (gpm/ sq. ft.)

11. Using the above calculation, what is Tinyown's loading rate? (*Choose one*)

a. 58 gpm/ sq. ft.
b. 0.023 gpm/ sq. ft.
c. 5.8 gpm/ sq. ft.
d. 42.9 gpm/ sq. ft
e. 0.23 gpm/ sq. ft.

(Answer: b. – 0.023 gpm/ sq. ft.)

2. Since the DEP maximum loading rate for a slow sand filter is 0.1 gpm/sq. ft., using the answer to Calculation question #1, is Tinyown's loading rate exceeding the allowable rate?

   a. yes.
   b. no

(Answer: b. – they aren't exceeding the allowable rate since 0.023 gpm/ sq. ft. is less than 0.1 gpm/sq. ft.)

Exercise

Unit 4 – Exercise

Fill in the blank:

1. An operator of a slow sand filtration facility should note and record certain items daily, weekly, and monthly.

Put a "D" in front of items that should be checked daily, "W" for items to be checked weekly and "M" for items to be checked monthly.

__D__ rate of flow
__D__ head loss
__W__ lubricate equipment
__D__ water temperature
__W__ chemical inventory
__M__ calibrate on-line analytical equipment
__D__ effluent turbidity
__D__ chlorine residual
__D__ storage facilities
__M__ verify proper functioning functions of safety equipment)

Matching – Match the slow sand records with the corresponding description:

__2_	A. Sampling Records	1. Raw and finished turbidity, finished chlorine, and dissolved oxygen at various locations in the process
__5_	B. Maintenance Records process	2. Log of date, time, and locations taken for SWDA compliance
__3_	C. Filter Operation/Cleaning Records	3. Includes amount removed, comments on the condition of the sand, and resanding records
__1_	D. Analytical Records	4. Includes the date maintenance was performed and the employee(s) that did the work
__4_	E. Equipment Records	5. Shop drawings, as-built drawings, and plant flow schematics