# PREPARATION AND PRACTICE

# FOR THE

# ENGINEERING SELECTION MODULE

# (ESM)

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# PREPARATION AND PRACTICE FOR THE ENGINEERING SELECTION MODULE (ESM)

This material is designed to provide you an opportunity to understand the content of the Engineering Selection Module (ESM) and to practice responding to questions similar to those on the ESM.

The Engineering Selection Module (ESM) is the secondary test for some positions in Verizon. The ESM is designed to assess your ability to learn and perform certain jobs which involve engineering-related principles and functions. Research has supported that those candidates who perform well on the ESM also tend to perform well in these positions.

On the ESM, you will be given two and one half hours to review background information about a fictitious company and to answer 53 multiple choice questions based upon that information. The information that is provided is similar to the type of information you would work with in performing some tasks requiring engineering principles and functions.

You may not use a calculator during the actual test; therefore, you should not use a calculator during this preparation and practice. You will be given scratch paper for use during the test. Keep your scratch paper organized in a way that makes it easy to locate the calculations that you worked for a particular problem because the answer to one problem may require calculations you performed for a previous problem.

The form of the ESM you are given will be based upon either a fictitious gas company or a fictitious water company. It will not matter to you which form you are given because both forms are at the same level of difficulty. Though this preparation deals with a fictitious water company, the preparation and practice should be useful regardless of which form of the ESM you are given.

The ESM begins with several pages of data related to the fictitious company followed by a series of questions based upon the data. This preparation and practice follows the same format. Strive for accuracy, but complete as many items as you can.

# PREPARATION AND PRACTICE

The Neptune Water Company is the fictitious company about which you will be reading and responding to questions in this preparation and practice material. This company is divided into three districts with three classes of customers. The Engineering Department at the Neptune Water Company forecasts usage based upon present and past usage. You will be able to assume that a district's usage will remain consistent with the two most recent years' usage. In other words, if during 2002, a district used 1,000 gallons of water per hour and if during 2003 the same district used 1,500 gallons of water per hour, you will be able to assume that the forecast for the next year for that district would be 2,000 gallons of water – a consistent increase of 500 gallons per hour

.

The following table presents data about three districts and three classes of customers (users).

**Table 1: DISTRIBUTION OF CLASSES OF CUSTOMERS (For all years)**

| District | Irrigation Hydrants | Houses | Commercial/Apts. |
|---|---|---|---|
| Hawksbill | 87.50% | 50% | 25% |
| Lake City | 0% | 50% | 0% |
| Culpepper | 12.50% | 0% | 75% |

Notice that the three districts are: Hawksbill, Lake City and Culpeper.

Notice that the three classes of customers are: irrigation hydrants, houses, and commercial/apartments.

To familiarize you with this table, answer these questions:

1. Which district has the greatest percentage of irrigation hydrants?
2. Which district has the smallest percentage of commercial/apartments?
3. What percentage of houses is in Lake City?
4. Which two districts have the same percentage of houses?

ANSWERS

1. Hawksbill
2. Lake City
3. 50%
4. Hawksbill and Lake City

**Table 2: AVERAGE MONTHLY USAGE BY CLASS OF CUSTOMERS**

| | Hundreds of Gallons Per Month |
|---|---|
| Irrigation Hydrants | 504.23 |
| Houses | 24.56 |
| Commercial/Apts | 13.84 |

This table presents the number of hundreds of gallons per month used by each of the three classes of customers. Think about 35 hundreds of gallons per month (CGM). How many gallons is that actually? That would be equal to 3,500 gallons per month. To convert a number that represents hundreds of gallons per month to gallons per month, multiply by 100, or simply move the decimal point two places to the right.

35 hundreds of gallons per month (CGM) = 35 x 100 = 3,500 gallons per month
or
move the decimal point two places to the right 35. = 3500.

.
If you look at the table above now, how many gallons per month would 504.23 hundreds of gallons per month be equal to?

504.23 hundreds of gallons per month (CGM) = 504.23 x 100 = 50,423. gallons per mo.
or
move the decimal point two places to the right 504.23 = 50,423.

**Table 3: NUMBER OF CUSTOMERS FOR THE LAST 3 YEARS**

| Year | Hydrants | Houses | Commercial/Apts. |
|---|---|---|---|
| 2003 | 112 | 4,810 | 1,584 |
| 2002 | 82 | 4,958 | 1,475 |
| 2001 | 64 | 5,125 | 1,384 |

As stated previously, you will be able to assume that the amount of growth or loss established during the two most recent years will be repeated from the most recent year to the next year. (In this case, that would be 2004.)

Following are questions, much like those on the actual ESM, based upon the tables you have just seen and two others. These questions comprise the "Practice Exercise". Many of the questions that follow require that you perform several calculations and steps to arrive at an answer. You will find out very quickly that even the beginning questions require that you take more than one step. You should expect that this may be the case for problems on the ESM.

Following the "Practice Exercise" is a section entitled "Answers Explained". There are several ways that you may want to use this material:

1. You may want to complete the section entitled "Practice Exercise" without looking at the answers that follow until you have completed all items on the "Practice Exercise".

OR

2. You may want to attempt a problem and then check the answer provided in "Answers Explained" section for that problem before going on to another problem.

OR

3. If you find this material particularly challenging, you may want to go to the "Answers Explained" section even before you work the problems to see how problems of these types are solved.

You will determine very quickly which approach is best for you.

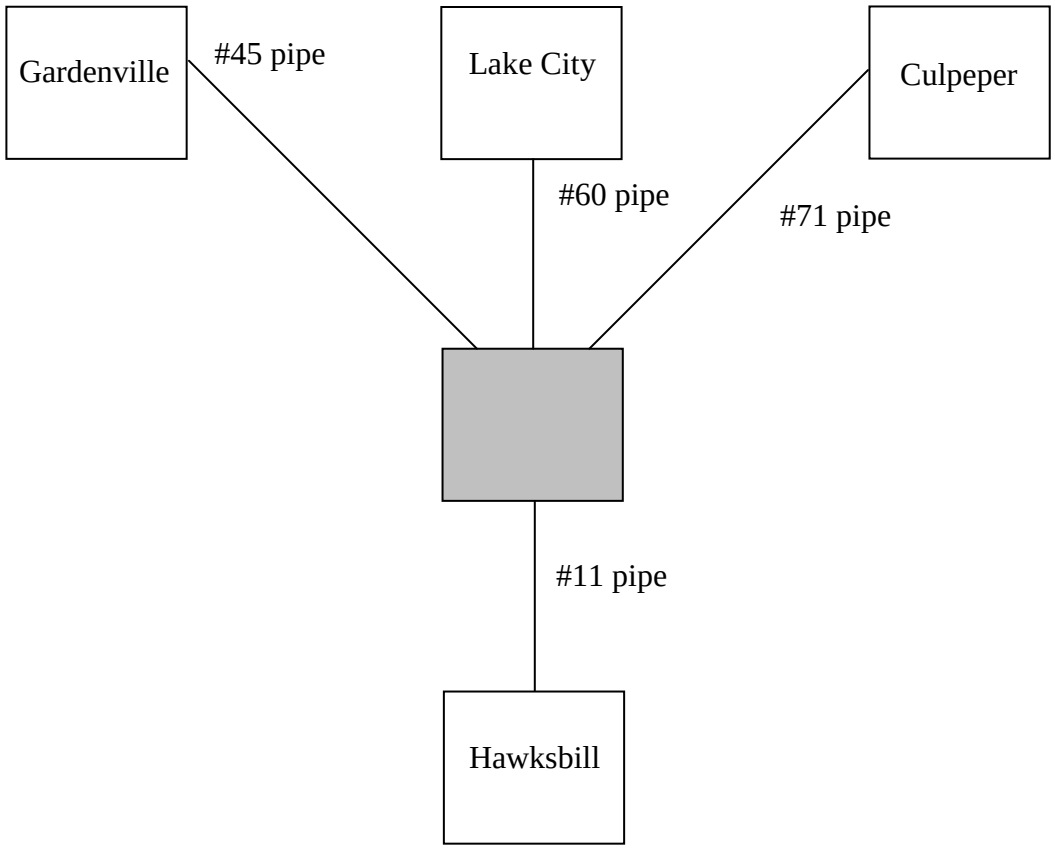
Success on the ESM requires not only the ability to solve mathematical problems but also the ability to reason in hypothetical situations involving real-life engineering-related situations. At the end of this preparation material, you will be given some resources to consider if you need more help in performing the mathematical calculations and in understanding how to solve word problems.

Though this preparation and practice material may be useful to you in learning more about the ESM and in preparing for the ESM, your completion of this material does not guarantee that you will qualify on the actual ESM. Success on any company qualification test depends upon many factors.

It is always a good idea to talk with a FutureLink Advisor to learn if the position to which you aspire is a good match for you based upon your skills, interests and values.

Now, following are the two additional tables (Table 4 and Table 5) you will need to refer to as you work through the "Practice Exercise". Take a brief look at the tables and, then, begin the "Practice Exercise".

**Table 4: Neptune Water Company - Water Main Map**



## Table 5: Pipe Size – Pipe Capacity

| Pipe size | Capacity in GPH | Pipe size | Capacity in GPH |
|---|---|---|---|
| 81 | 500 | 41 | 20500 |
| 80 | 1000 | 40 | 21000 |
| 79 | 1500 | 39 | 21500 |
| 78 | 2000 | 38 | 22000 |
| 77 | 2500 | 37 | 22500 |
| 76 | 3000 | 36 | 23000 |
| 75 | 3500 | 35 | 23500 |
| 74 | 4000 | 34 | 24000 |
| 73 | 4500 | 33 | 24500 |
| 72 | 5000 | 32 | 25000 |
| 71 | 5500 | 31 | 25500 |
| 70 | 6000 | 30 | 26000 |
| 69 | 6500 | 29 | 26500 |
| 68 | 7000 | 28 | 27000 |
| 67 | 7500 | 27 | 27500 |
| 66 | 8000 | 26 | 28000 |
| 65 | 8500 | 25 | 28500 |
| 64 | 9000 | 24 | 29000 |
| 63 | 9500 | 23 | 29500 |
| 62 | 10000 | 22 | 30000 |
| 61 | 10500 | 21 | 31000 |
| 60 | 11000 | 20 | 32000 |
| 59 | 11500 | 19 | 33000 |
| 58 | 12000 | 18 | 34000 |
| 57 | 12500 | 17 | 35000 |
| 56 | 13000 | 16 | 36000 |
| 55 | 13500 | 15 | 37000 |
| 54 | 14000 | 14 | 38000 |
| 53 | 14500 | 13 | 39000 |
| 52 | 15000 | 12 | 40000 |
| 51 | 15500 | 11 | 41000 |
| 50 | 16000 | 10 | 42000 |
| 49 | 16500 | 9 | 43000 |
| 48 | 17000 | 8 | 44000 |
| 47 | 17500 | 7 | 45000 |
| 46 | 18000 | 6 | 46000 |
| 45 | 18500 | 5 | 47000 |
| 44 | 19000 | 4 | 48000 |
| 43 | 19500 | 3 | 49000 |
| 42 | 20000 | 2 | 50000 |

# PRACTICE EXERCISE

Use the five tables in the previous part of this material to answer the questions that follow. Do your work on scratch paper. Circle the letter of the correct answer. Organize your scratch paper so that you can find the computations and answers to problems you worked previously. Work quickly and accurately. (NOTE: In this "Practice Exercise," you will find that sometimes answers have been "rounded off". Check the answer you have determined to see if it appears as one of the multiple choice answers, but, if it does not, check to see if that answer has been "rounded off".

1. What was the total number of houses in Lake City during 2003?

   A. 4,810
   B. 2,405
   C. 4,968
   D. 2,479

2. What was the total number of hydrants in Culpeper in 2001?

   A. 8
   B. 12
   C. 16
   D. 64

3. What will be the estimated number of houses in the company for 2004?

   A. 4,958
   B. 5,136
   C. 4,662
   D. 4,868

4. What will be the estimated number of houses in the Hawksbill District for 2004?

   A. 4,662
   B. 2,331
   C. 4,632
   D. 2,316

5. What will be the estimated number of commercial/apartments in Culpeper for 2004?

   A. 984
   B. 1,653
   C. 1,654
   D. 1,270

6. What is the average usage of houses in the Lake City District in 2003 in gallons per hour (GPH)?

   A. 82
   B. 8,201.05
   C. 73,056.05
   D. 5,204

7. What is the average usage for Hawksbill in 2003 in gallons per hour (GPH)?

   A. 15,724.31
   B. 15,824.31
   C. 42,568.01
   D. 4,256.01

8. What is the average usage for Culpeper in 2003 in gallons per hour (GPH)?

   A. 4,519.38
   B. 3,127.38
   C. 3,261.38
   D. 3,905.28

9. What is the average usage for Hawksbill for the next year (2004) in gallons per hour (GPH)?

   A. 25,021
   B. 10,100
   C. 17,462.58
   D. 17,409.65

10. Based on the estimated usage for Culpeper for 2004, should the water main be enlarged?

    A. Yes
    B. No

11. New construction and fire codes state that all water mains should be increased by 10%. What size water main should be installed for the Hawksbill district?

    A. 78
    B. 42
    C. 43
    D. 44

## ANSWERS EXPLAINED

1. What was the total number of houses in Lake City during 2003?

| | |
|---|---|
| A. 4,810 | ANSWER: B |
| B. 2,405 | |
| C. 4,958 | |
| D. 2,479 | |

Table 3 shows the years and the numbers of customers for each of the three classes. The total number of houses in the company during 2003 is 4,810. According to Table 1, the percentage of the customer base in Salt City which is houses is 50%.

50% of 4,810 = .50 x 4,810 = 2,405

To find the % of a number, change the % to a decimal by moving the decimal point two places to the left. Then, multiply that decimal by the number on which the % is being taken. In this problem, 50% = .50 by moving the decimal point two places to the left. Then, multiply .50 x 4,810 (the number on which that % is being taken).

2. What was the total number of hydrants in Culpepper during 2001?

| | |
|---|---|
| A. 8 | ANSWER: A |
| B. 12 | |
| C. 16 | |
| D. 64 | |

Table 3 indicates that the total number of hydrants in the company was 64 in 2001. Table 1 indicates that hydrants are 12.50% of the customer base in Culpepper.

12.50% of 64 = .125 x 64 = 8

Just as in Problem #1, change the % to a decimal by moving the decimal point two places to the left. Then, multiply that decimal by the number on which that percent is being taken.

3. What will be the estimated number of houses in the Neptune Company in 2004?

| | |
|---|---|
| A. 4,958 | ANSWER: C |
| B. 5,136 | |
| C. 4,662 | |
| D. 4,868 | |

Remember, that you were advised that you should assume that the gain or loss for the two years previous to the year to be forecasted will be consistent. You are asked to forecast 2004. During 2003, the total number of houses was 4,810. During 2002, the number of houses was 4,958. There was, therefore, a decrease of 148 houses from 2002 to 2003.

4,810 (The number of houses during 2003)
4,958 (The number of houses during 2002)
148 (The decrease in the # of houses from 2003 to 2002)

Assuming the loss (or gain) to be consistent for 2004, the number of houses you will forecast for 2004 is 4,662.

4,810 (The number of houses in 2003)
-148 (The decrease in the # of houses lost from 2003 to 2002)
4,662 (The number of houses you would forecast for 2004)

NOTE: If the amount of decrease were consistent from 2004 to 2005, the number of houses you would forecast for 2005 would be 4,662 – 148 or 4,514. As long as the loss (or gain) were consistent from one year to the next, you could forecast for any number of years in the future.

4. What will be the estimated number of houses in Hawksbill for 2004?

| | |
|---|---|
| A. 4,662 | ANSWER: B |
| B. 2,331 | |
| C. 4,632 | |
| D. 2,316 | |

For this problem, you will be able to use some of the calculations you performed in the previous problem. You determined in Problem #3 that the estimated number of houses in the Neptune company was for 2004 was 4,662. If you now refer to Table 1, you will notice that the percentage of houses in Hawksbill is 50%. 50% of the 4,662 houses that comprise the three districts equals 2,331 houses.

4,662 (estimated # of houses in 2004)
50% (% of houses in Hawksbill)

4,662
x .50 (% of houses in Hawksbill converted to a decimal)
2,331 (estimated # of houses in Hawksbill for 2004)

5. What will be the estimated number of commercial/apartments in Culpeper for 2004?

| | |
|---|---|
| A. 984 | ANSWER: D |
| B. 1,653 | |
| C. 1,564 | |
| D. 1,270 | |

1,584 (commercial/apts. in company in 2003)
- 1,475 (commercial/apts. in company in 2002)
109 (difference in the # of commercial/apt.s)

1,584 (commercial/apts. in company in 2003)
+ 109 (difference in the # of apartments)
1,693 (estimated # of commercial/apartments in the company in 2004)

1,693 (estimated # of commercial/apartments in 2004)
x .75 (percentage of commercial/apartments in Culpeper converted to
1,269.75 or 1270 apartments in Culpeper in 2004

Can you understand why it is important to organize your scratch work so that you can easily find the answers from previous calculations?

6. What is the average usage for houses in the Lake City District in 2003 in gallons per hour?

| | |
|---|---|
| A. 82 | ANSWER: B |
| B. 8201.05 | |
| C. 73,056 | |
| D. 5,204 | |

For some questions on the ESM, you will need to convert the average monthly usage from Table (Table 2) from hundreds of gallons per month to gallons per hour (GPH). To do this, move the decimal point two places to the right. Moving the decimal point to the right two places is the same as multiplying by 100.

504.23 hundreds of gallons per month = 50,423 gallons per month

Because there are 30 days per month (on average) and 24 hours in a day, there are 720 hours in a month. (30 days x 24 hours = 720 hours)

To change gallons per month to gallons per hour, divide by 720. The number of gallons per hour used will be far less than the number of gallons per month used.

50,423 gallons per month divided by 720 = 70.03 gallons per hour for hydrants.

2456 gallons per month divided by 720 = 3.41 gallons per hour for houses.

1384 gallons per month divided by 720 = 1.92 gallons per hour for commercial/apartments.

Now, back to the original question: What is the average usage for Lake City in 2003?

| | |
|---|---|
| 4,810 | (# of houses in 2003) |
| x .50 | (percentage of houses in Lake City converted to a decimal) |
| 2,405 | houses in Lake City (See problem #1) |
| x 3.41 | (usage for houses in gallons per hour) |
| 8,201.05 | gallons per hour |

7. What is the average usage for the Hawksbill District for 2003 in gallons per hour?

| | |
|---|---|
| A. 15,724.31 | ANSWER: B |
| B. 15,824.31 | |
| C. 42,568.01 | |
| D. 4,256.01 | |

To solve this problem, you will need to find the usage for hydrants in Hawksbill in gallons per hour, the usage for houses in Hawksbill in gallons per hour, and the usage for apartments in Hawksbill in gallons per hour. The sum of these three usages will be the total of average usage in Hawksbill.

To determine the usage of hydrants:

| | |
|---|---|
| 112 | (hydrants in the company) |
| x .875 | (% of hydrants in Hawksbill converted to a decimal |
| 98 | (hydrants in Hawksbill) |
| x 70.03 | (hydrant usage in gallons per hour) See Problem 6 |
| 6,862.94 | (hydrant usage in Hawksbill in gallons per hour) |

To determine the usage of houses:

| | |
|---|---|
| 4,810 | (# of houses in the company) |
| x .50 | (% of the houses in Hawksbill converted to a decimal) |
| 2,405 | (# of houses in Hawksbill) |
| x 3.41 | (house usage in gallons per hour) See Problem #6 |
| 8201.05 | (house usage in Hawksbill in gallons per hour) |

To determine the usage of commercial/apts.:

| | |
|---|---|
| 1,584 | (# of apartments in company in 2003) |
| x .25 | (% of apartments in Hawksbill converted to a decimal) |
| 396 | (# of apartments in Hawksbill) |
| x 1.92 | (gallons per hour) See Problem #6 |
| 760.32 | (apartment usage in Hawksbill in gallons per hour) |

You have now determined the average usage for each class of customers in Hawksbill. To determine the average usage for Hawksbill, add the average usages for the three classes of customers.

| | |
|---|---|
| 6862.94 | (hydrants) |
| 8201.05 | (houses) |
| + 760.32 | (commercial/apts.) |
| 15,824.31 | TOTAL |

8. What is the average usage for the Culpeper district in 2003 in gallons per hour?

| | |
|---|---|
| A. 4,519.38 | ANSWER: C |
| B. 3,127.38 | |
| C. 3,261.38 | |
| D. 3,905.28 | |

Again, the average usage for the Culpeper district will be the sum (total) of the average usages of the three classes of customers in Culpeper.

To find the average hydrant usage:

| | |
|---|---|
| 112 | (# of hydrants in the company) |
| x .125 | (% of hydrants in Culpeper converted to a decimal) |
| 14 | (# of hydrants in Culpeper) |
| x 70.03 | (average hydrant usage in gallons per hour) See Problem #6 |
| 980.42 | (hydrant usage in Culpeper in gallons per hour) |

To find the average usage by commercial/apts.:

| | |
|---|---|
| 1,584 | (# of apartments in the company) |
| x .75 | (% of apartments in Culpeper converted to a decimal) |
| 1,188 | (# of commercial/apts. in Culpeper) |
| x 1.92 | (average apartment usage in gallons per hour) See Problem #6 |
| 2,280.96 | (apartment usage in Culpeper in gallons per hour) |

To find the average usage for Culpeper in 2003 in gallons per hour, add the usage for hydrants and apartments. If you refer to Table 1, you will note that houses are not part of the customer base in Culpeper.

| | |
|---|---|
| 980.42 | (hydrants) |
| + 2,280.96 | (commercial/apts.) |
| 3,261.38 | TOTAL |

In problem #9, we are going to have a slightly more complicated problem to solve. We are still going to determine the average usage for one of the districts; however, we are going to determine this for a future year, 2004. This will really not be much more difficult though it will involve an additional step, estimating usage for 2004.

9. What is the average estimated usage for Hawksbill for 2004 in gallons per hour?

| | |
|---|---|
| A. 25,021 | ANSWER: C |
| B. 17,465.99 | |
| C. 17,462.58 | |
| D. 17,409.65 | |

As we have done previously, we will forecast the number of customers for 2004.

| Hydrants | | Houses | | Apartments | |
|---|---|---|---|---|---|
| 112 | (2003) | 4,810 | (2003) | 1,584 | (2003) |
| - 82 | (2002) | -4,958 | (2002) | - 1,475 | (2002) |
| 30 | (gain) | - 148 | (loss) | 109 | (gain) |
| 142 | (2004 est.) | 4,662 | (2004 est.) | 1,693 | (2004 est.) |
| x 87.50% | (% in Hawksbill) | x 50% | (% in Hawksbill) | x 25% | (% in Hawksbill) |
| 124.25 | (# in Hawksbill) | 2,331 | (# in Hawksbill) | 423.25 | (# in Hawksbill) |
| x 70.03 | (avg. usage hydrant) | x 3.41 | (avg. usage house) | x 1.92 | (avg. usage apt.) |
| 8,701.23 | hydrant usage GPH | 7,948.71 | house usage GPH | 812.64 | apt. usage GPH |

Total estimated usage for Hawksbill for 2004 will be the sum (total) of the estimated usages for the three classes of customers.

| | |
|---|---|
| 8,701.23 GPH | (hydrant) |
| 7,948.71 GPH | (houses) |
| + 812.64 GPH | (commercial/apts.) |
| 17,462.58 GPH | TOTAL |

10. Based on the estimated usage for Culpeper for 2004, should the water main size be replaced?

| | |
|---|---|
| A. Yes<br>B. No | ANSWER: B |

| | |
|---|---|
| 142 | (est. # of hydrants in 2004) |
| x .125 | ( % of hydrants in Culpeper converted to a decimal) |
| 17.75 | (est. # of hydrants in Culpeper in 2004) |
| x 70.03 | (avg. usage for hydrants in gallons per hour) |
| 1,243.03 | GPH (est. usage for hydrants in Culpeper in 2004 |

| | |
|---|---|
| 1693 | (est. # of apts. in 2004) |
| x .75 | (% of apts. in Culpeper converted to a decimal) |
| 1,269.75 | (est. # of apts. in Culpeper 2004) |
| x 1.92 | (avg. usage for commercial/apts. in gallons per hour) |
| 2,437.92 | GPH (est. usage for commercial/apts. in Culpeper in 2004) |

According to Table 1, there are no houses in Culpeper.
Now that we have found the estimated usage for the two classes of customers in Culpeper, we can add these to find the total estimated usage for Culpeper in 2004.

| | |
|---|---|
| 1,243.03 | (hydrants) |
| + 2,437.92 | (commercial/apts.) |
| 3,680.95 | TOTAL |

Now, look at the chart entitled "Neptune Water Company – Water Main Map" and the table which lists pipe sizes and capacity in GPH.

The current pipe size to Culpeper is #71, which is rated at 5,500 GPH. This is more than adequate to handle 3,680.95 GPH. The water main does not need to be replaced.

11. New construction and fire codes for the future state that all water mains should be increased by 10%. What size water main should be installed for the Hawksbill District?

| | |
|---|---|
| A. 78 | ANSWER: C |
| B. 29 | |
| C. 43 | |
| D. 10 | |

Refer to Problem #9 which shows that the total estimated usage for Hawksbill for 2004 is 17,462.58 GPH. If this were increased by 10%, then you would need to compute 10% of 17,462.58:

10% of 17,462.58 = .10 x 17,462.58 = 1,746.258

You would then add 17,462.58 and 1,746.258 to find the increased usage.

$$\begin{array}{r} 17{,}462.580 \\ +\ 1{,}746.258 \\ \hline 19{,}208.838 \end{array}$$

Now, look at the table of pipe sizes and capacities. A new pipe size 43 would meet the new requirements because a pipe size 43 has a capacity of 19,500 GPH.

## RESOURCES

For assistance with mathematical computations:

FutureLink Mastering Math Home Study Course

ALEKS Online Math Program

Basic math course at the local community college

Math text available at local book store

Areas of math to study:

Computations with whole numbers, decimals and percents

Basic algebra for problem solving

Techniques for solving word problems