Problem of the Day

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A wastewater treatment pond has a surface area of 56 acres and is operated at a depth of 5.25 feet. The average daily flow to the pond is 2.13 MGD. What is the detention time (days) in this pond?

Introduction

Operators are frequently asked to calculate how long it will take to fill a tank or reservoir, how long it will take to empty a tank or a reservoir, or the detention time in a tank or reservoir. It is always the same equation:

$$\text{Time} = \frac{V}{Q}$$

where V is volume and Q is the flow rate into or out of that volume. Again, this is the same equation whether you're calculating fill time, empty time or detention time.

Today's problem states the "average daily flow to the pond is 2.13 MGD," so we know the Q in this equation. What about the V? We are given surface area (A) and depth (d_{epth}). (Notice the variable I'm using for depth, d_{epth}. I do this because I use d to designate the unit of time, days. You can use any variable name you want. Don't let that confuse you.) Can surface area and/or depth be used to calculate volume? Absolutely.

$$V = A \times d_{epth}$$

This little equation gets used a lot. Make sure you understand it. Indeed, if I knew the surface area of all the oceans in the world and their average depth, it would be a simple calculation to find the volume of the world's oceans.

So our Time equation above becomes:

$$\text{Time} = \frac{A \times d_{epth}}{Q}$$

or in total solution bridge format:

$$\text{Time} = \frac{A \mid d_{epth}}{Q \mid}$$

We can remember these equations or just let the units tell us what to do.

Solution

The question asks to calculate detention time in days. These units, therefore, are entered between heavy vertical lines followed by an equals sign and the blank solution bridge.

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$$\left| \text{d} \right| = \frac{\text{d} \quad \text{Mgal} \quad 56\ \text{ac} \quad 5.25\ \text{ft}}{2.13\ \text{Mgal} \quad 3.069\ \text{acft}}$$

Three pieces of information are given in the problem:

1. Surface area, A = 56 ac
2. Operating depth, d_{epth} = 5.25 ft
3. Flow = 2.13 Mgal/d (WWTT strongly recommends that MGD **never** be used)

If we forgot the equation for calculating fill time, empty time or detention time, we can just start out by getting the units needed in the answer. When a unit is all by itself like d is on the lefthand side of the equals sign, it is understood to be in the numerator. In order to get d from 2.13 Mgal/d (No. 3 in our list of givens) in the numerator of the solution bridge, we enter 2.13 Mgal in the denominator, which means we're dividing by the flow. Remember whenever we say "per," such as "2.13 Mgal per day," we move to the other side of the solution bridge. Doing so gets d in the numerator of the solution bridge where we need it as shown in bold.

d	=	**d**	
		2.13 Mgal	

With this one entry, we have the units on the solution bridge that we need in the answer. To proceed, we cancel out all other units until we only have what we need in the answer. But wait. We don't have the units Mgal anywhere in the list of givens. We have units of ac and ft. What to do?

We enter the holy grail conversion factor for pond problems, 3.069 ac·ft/Mgal, so Mgal cancels. Remember, we can put any conversion factor we want on any solution bridge because a conversion factor is just equal to the number 1. But it helps if the conversion factor has a purpose. We could enter 1,000,000 gal/Mgal so Mgal cancels but then we'd have to convert gal to ft3 and then ft2 to ac, but we could do it. It wouldn't be wrong, it would just be more work for us. So let's take the easy way out.

d	=	**d**	~~Mgal~~	
		2.13 ~~Mgal~~	3.069 ac·ft	

Next we cancel ac using No. 1 in our list.

d	=	**d**	~~Mgal~~	56 ~~ac~~	
		2.13 ~~Mgal~~	3.069 ~~ac~~·ft		

Next we cancel ft using No. 2 in our list.

d	=	**d**	~~Mgal~~	56 ~~ac~~	5.25 ~~ft~~
		2.13 ~~Mgal~~	3.069 ~~ac·ft~~		

Notice because V equals A times d_{epth}, the units have told us exactly what the equation above told us to do: to calculate time (fill time, empty time or detention time), divide volume (V) by flow (Q). The only other thing we have to do is to use the conversion factor to cancel the unwanted units.

Because all the units have canceled except those needed in the answer, **d**,we know the solution bridge is complete and the arithmetic gives the answer:

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d	=	**d**	~~Mgal~~	56 ~~ac~~	5.25 ~~ft~~
		2.13 ~~Mgal~~	3.069 ~~ac·ft~~		

56 × 5.25 ÷ 2.13 ÷ 3.069 = **45 d**.

Discussion

Again, it doesn't matter if you're ask to calculate how long it will take to fill a tank or reservoir, how long it will take to empty a tank or a reservoir, or the detention time in a tank or reservoir, it is always the same equation. Always.

$$\text{Time} = \frac{V}{Q}$$

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.