Problem of the Day
2014.Sept.30

Discussion

Good old "pond problems."

Detention time in ponds is reported in units of days. As discussed in the 2014.Sept.22 Problem of the Day, wastewater treatment plant operators often have to calculate how long it takes to fill a tank or a reservoir, how long it takes to empty a tank or a reservoir, or what the detention time is in a tank or a reservoir. Whenever a question arises asking about time and includes a volume (V) and flow rate (Q), the equation will be the same:

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

Again, this is the equation that will be used for every question asking about fill time, empty time or detention time. All that is needed to do the calculation is the volume and flow rate and the units required in the answer.

We make pond math problems way harder than they need to be, as discussed previously. In most pond problems, influent flow is given in Mgal/d (MGD) and the area of the pond is given in acres. Even if area isn't given in acres, it is a simple matter to convert ft^2 (area) into ac with the conversion factor known to most operators:

$$\frac{43{,}560\ ft^2}{ac} \quad \text{or} \quad \frac{ac}{43{,}560\ ft^2}$$

If ac and Mgal are both in a pond problem on opposite sides of the equals sign (=) or on opposite sides of the railroad track, the conversion factor that is most useful is:

$$\frac{3.069\ ac\cdot ft}{Mgal} \quad \text{or} \quad \frac{Mgal}{3.069\ ac\cdot ft}$$

Problem

Now for today's problem.

Problem of the Day: The City's 65-acre wastewater treatment pond receives an average 2.3 MGD of flow with a BOD of 180 mg/L. The pond is 5 feet deep. What is the pond's detention time in days?

Solution

The first thing we have to do is identify what units are needed in the answer. The question is very straightforward and asks for “days.” So, “d” is entered between heavy vertical lines followed by the equals sign and the blank track.

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$$\left| d \right| = \frac{65\ \text{ac} \quad 5\ \text{ft} \quad d \quad \text{Mgal}}{2.3\ \text{Mgal} \quad 3.069\ \text{ac·ft}}$$

The equation above is used to populate the railroad track first with volume, V, in the numerator and flow, Q, in the denominator. But what is the volume? Volume is always the surface area times the depth, both of which we know in this problem. So that is how the railroad track is started.

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$$\left| d \right| = \frac{65\ \text{ac} \quad 5\ \text{ft} \quad \quad}{\quad \quad \quad \quad}$$

This is followed by entering the flow in the denominator.

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$$\left| \mathbf{d} \right| = \frac{65\ \text{ac} \quad 5\ \text{ft} \quad \mathbf{d} \quad \quad}{\quad \quad \quad \quad 2.3\ \text{Mgal} \quad \quad}$$

The desired answer units, d, are now in the railroad track, but all the other units (ac, ft and Mgal) have to be canceled. To the rescue: the holy grail of conversion factors in pond math whenever acres (ac) and million gallons (Mgal) are on opposite sides of the railroad track: 3.069 ac·ft/Mgal.

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$$\left| \mathbf{d} \right| = \frac{65\ \cancel{\text{ac}} \quad 5\ \cancel{\text{ft}} \quad \mathbf{d} \quad \cancel{\text{Mgal}}}{\quad \quad \quad \quad 2.3\ \cancel{\text{Mgal}} \quad 3.069\ \cancel{\text{ac·ft}}}$$

Since all the units have been canceled except d needed in the answer (shown in bold), the math is complete and the arithmetic gives the answer:

65 x 5 ÷ 2.3 ÷ 3.069 = <u>46.0 d</u>.