Problem of the Day

2015.Jul.12

Problem of the Day

The Blue River just upstream of Green Mountain Reservoir between Silverthorne and Kremmling, Colorado, is 132.5 feet across with an average depth of 4.8 feet. Twenty velocity measurements across the river at various depths averaged 4.65 ft/s. Calculate the river's flow in cubic feet per second.

Introduction

This is a question somewhat based on my own experience. I started working my first job as an operator at a wastewater treatment plant in April 1978 at the Silverthorne/Dillon Joint Sewer Authority's Blue River Wastewater Treatment Plant. There was an ongoing study looking at the phosphorus load to Green Mountain Reservoir, which was several miles downstream of the plant's outfall. That first summer, my first in Colorado, the chief plant operator would take me on the monthly sampling trips. We'd join the Green Mountain Reservoir dam operator and take his boat out on the reservoir to collect samples. It was so amazing; I fell in love with wastewater treatment! Returning to the plant, we'd stop at several designated places along the Blue River to sample. At each, we'd estimate the flow of the river using today's Problem of the Day calculation.

Mathematically, the relationship between flow rate (Q), area through which the flow is passing (A) and the velocity of flow (v) is:

$$v = \frac{Q}{A}$$

But unlike the last two Problems of the Day, we are not asked to calculate velocity given Q and A. Instead, we are calculating Q given A and v. From this equation, we easily derive the equation we need for calculating Q:

$$Q = A \times v$$

Solution

The question asks to calculate flow in cubic feet per second. These units of flow are often abbreviated "cfs." WWTT doesn't do this because it is easy to lose sight of the fact that it is cubic feet **per** second. The July 5, 2015, Problem of the Day (http://wastewatertechnologytrainers.com/wp-content/uploads/2015/07/2015.Jul_.05.pdf) discussed how the use of "MGD" in the solution bridge got one student in trouble when he multiplied rather than divided to cancel d. So, not cfs, but ft^3/s. These are the units needed in the answer so, as always, they are put between heavy vertical lines followed by the equals sign and the blank solution bridge.

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$$\left| \frac{ft^3}{s} \right| = \_\_\_\_\_$$

We use the second equation given above, because we are finding Q, to start the solution bridge. In order to calculate Q, we have to multiply A times v. The area through which the river flow was passing is just the width of the river times the average depth (note, we're not talking about surface area here), and velocity is entered just like it's given in the problem statement.

$$\left| \frac{\mathbf{ft^3}}{\mathbf{s}} \right| = \left| \frac{132.5\ \mathbf{ft} \quad 4.8\ \mathbf{ft} \quad 4.65\ \mathbf{ft}}{\qquad\qquad\qquad\quad \mathbf{s}} \right|$$

That's it! Because the only units on the solution bridge are those required in the answer, the solution bridge is complete and the arithmetic gives the answer.

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$$\frac{\mathbf{ft^3}}{\mathbf{s}} = \frac{132.5\ \mathbf{ft} \quad 4.8\ \mathbf{ft} \quad 4.65\ \mathbf{ft}}{\mathbf{s}}$$

132.5 x 4.8 x 4.65 = **2,957 ft^3/s**.

Discussion

As I have always said, if the units work out, you know you've done the problem correctly.

This is actually a lot of flow. Convert this to Mgal/d. I get 1,912 Mgal/d. That would be a really big treatment plant!

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.