CH2MHILL

Back to Basics Math for Operators

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2013 Hands-On Operator Training Day
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Derived from WE&T article

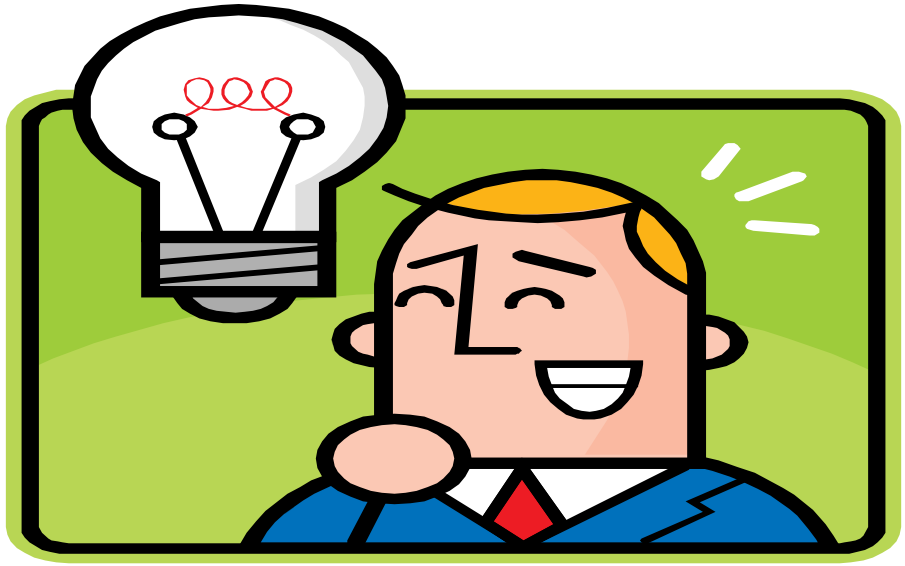
“How to Solve Mathematical Word Problems in Wastewater”

by Mike Ross 4/2007 pp 64-66

http://www.wef.org/publications/page_wet.aspx?id=4690&page=ca&section=Logical Math

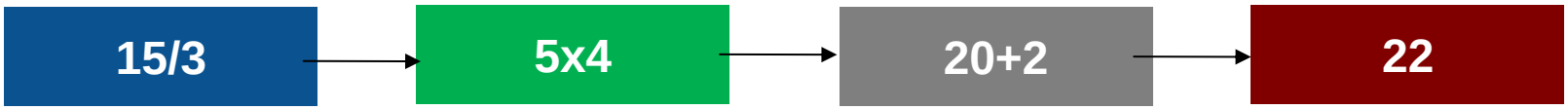
Why Learn Problem Solving?

- Higher certification
- Solve problems at work/plant
- Step by step logic – apply to other situations
- Build confidence in ability
- Promotions?



First the really basics…

- Basic Mathematical Functions
  - Exponents
  - Division/Multiplication,
  - Addition/Subtraction
  - Roots (sq, cube, etc.)
- Order
  - PEMDAS (Please Excuse My Dear Aunt Sally)
    - Parentheses, Exponents, Multiply/Divide, Addition/Subtraction
    - Then left to right for equal order tasks (i.e. multiply/divide or add/subtract)
  - 15/3x4+2 =?



Water/Wastewater basics…

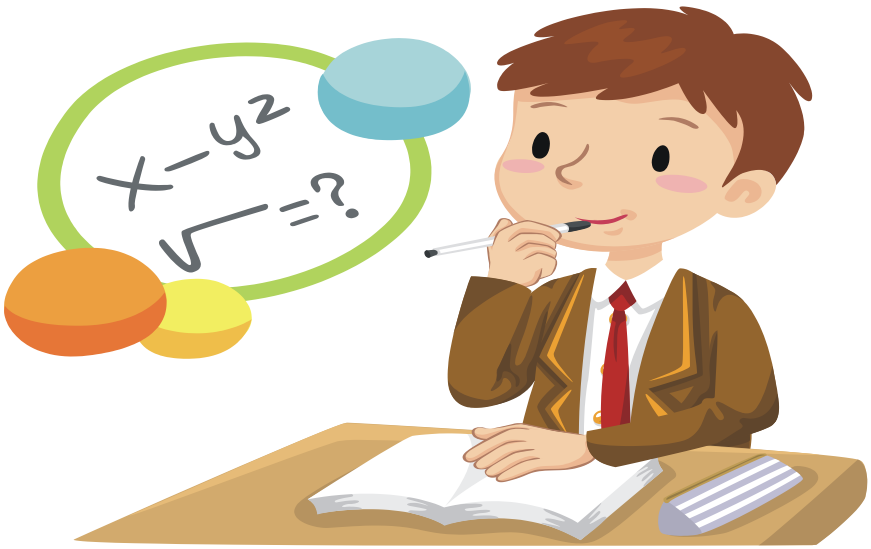
- Conversions
  - 1 gallon of water = 8.34 lbs
  - 1 cu ft (or ft^3)= 7.48 gallons
  - 1 grain/gal = 17.1 mg/l (or ppm)
  - 1 psi = 2.31 ft of water
  - 1 hp = 746 Watts
- Formulas
  - Lbs = MG x 8.34 x mg/l x SG
  - Q = V x A
  - HDT = V/Q
  - V = distance/time
  - Area of circle = pi x r^2

Dang it, Jim, I'm an *operator* not a mathematician…

…let's get back to problem solving.

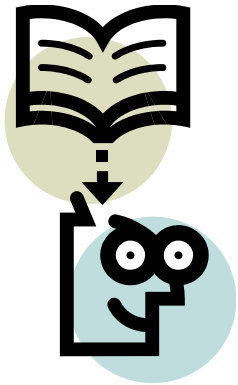
Paths to take

- Work backwards
- Follow the units
- Ignore the junk
- Write it down
- Double check



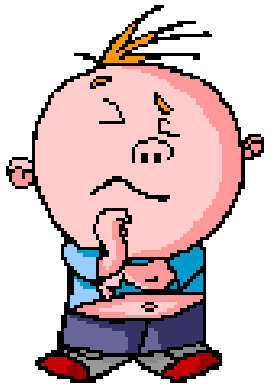
Work Backwards?

- First – FIND THE QUESTION
  - Determine what the question asking
  - This might be at the END of the paragraph
- Now - READ THE PROBLEM
  - NOTE: the problem and the question may be two different things when it comes to story problems
- Think about real life – what do you need data-wise?
- Now reread and look for data again



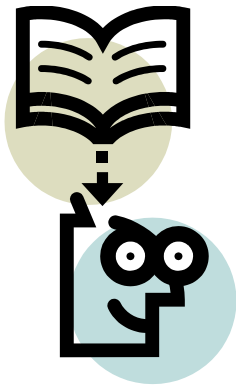
Example

- The Clean Water Wastewater Treatment Plant is converting from fixed film treatment to activated sludge. The CWWWT Plant Manager is interested in learning more so he visits a neighboring plant to see how they control their process. The CWWWT Plant Manager sees that the Bugville WWTP can use mass balance calculations to show how the sludge blanket levels will increase and decrease due to changes in diurnal flow conditions at the BWWTP. What is the airspeed velocity of a fully laden Swallow in MPH?
- Use the data below to evaluate questions.
  - Morning influent flow rate 10 MGD (37,854 m3/day)
  - Afternoon influent flow rate 40 MGD (151,420 m3/day)
  - MLSS = 2700 mg/l; MLVSS = 2250 mg/l; RAS = 7400 mg/l
  - RAS rate (constant) 9 MGD (34,069 m3/day)
  - Core sample solids in clarifier 5200 mg/l
  - Number of final clarifiers 6
  - Clarifier diameter 120 ft (36.6 m)
  - Sludge blanket depth in morning 1.5 ft (0.46 m)
  - Clarifier floor slope 0%
  - Operator age 29 years
  - Swallow velocity = 35.2 ft/sec
  - Sludge age (MCRT) 10 days



Work Backwards?

- First – FIND THE QUESTION
  - "What is the airspeed velocity of a fully laden Swallow in MPH?"
- Now - READ THE PROBLEM
  - NOTE: the problem and the question may be two different things when it comes to story problems
- Think about real life – what do you need data-wise?
  - You need to know airspeed right?
- Now reread and look for data again
  - Any tricks here…besides the question?



A more realistic example:

- The Clean Water Wastewater Treatment Plant is converting from fixed film treatment to activated sludge. The CWWWT Plant Manager is interested in learning more so he visits a neighboring plant to see how they control their process. The CWWWT Plant Manager sees that the Bugville WWTP can use mass balance calculations to show how the sludge blanket levels will increase and decrease due to changes in diurnal flow conditions at the BWWTP. How much MLSS in lbs/hr discharge to the secondary settling tanks during the morning flow conditions?
- Use the data below to evaluate questions.
  - Morning influent flow rate 10 MGD (37,854 m3/day)
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  - Core sample solids in clarifier 5200 mg/l
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  - Clarifier diameter 120 ft (36.6 m)
  - Sludge blanket depth in morning 1.5 ft (0.46 m)
  - Clarifier floor slope 0%
  - Operator age 29 years
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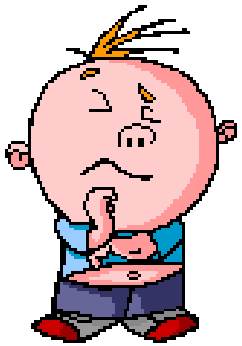
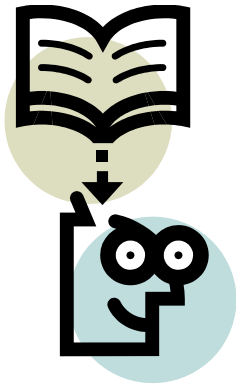


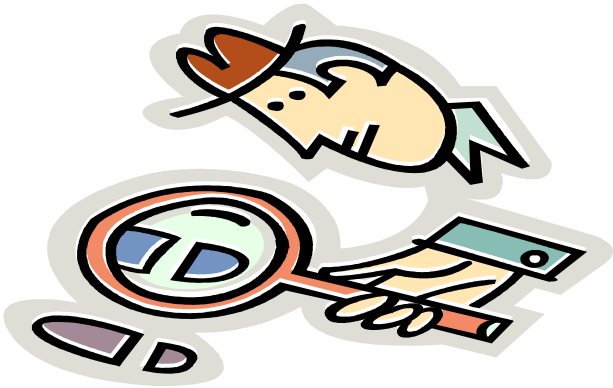
Work Backwards?

- First – FIND THE QUESTION
  - "How much MLSS in lbs/hr discharge to the secondary settling tanks during the morning flow conditions?"
- Now - READ THE PROBLEM
  - You find out why the operator wants to know this
  - You see there is ample information…maybe too much…
- Think about real life – what do you need data-wise?
  - What do you need to calculate pounds?
- Now reread and look for data again
  - Any tricks here?
    - Note lbs/hr NOT lbs/day…



Follow the Units

- Units are clues
  - What does gal/day/sq ft tell you?
  - What does lbs/day tell you?
  - OR from the example lbs/hr?
- Per or “/” means divide
  - This is a HUGE clue on how to set up a problem
- Convert given data to the units in the answer
- See web resources at end for more hints



Back to the example:

- The Clean Water Wastewater Treatment Plant is converting from fixed film treatment to activated sludge. The CWWWT Plant Manager is interested in learning more so he visits a neighboring plant to see how they control their process. The CWWWT Plant Manager sees that the Bugville WWTP can use mass balance calculations to show how the sludge blanket levels will increase and decrease due to changes in diurnal flow conditions at the BWWTP. What is the solids loading rate to the clarifiers in the morning in lbs/day/sq ft?
- Use the data below to evaluate questions.
  - Morning influent flow rate 10 MGD (37,854 m3/day)
  - Afternoon influent flow rate 40 MGD (151,420 m3/day)
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  - Number of final clarifiers 6
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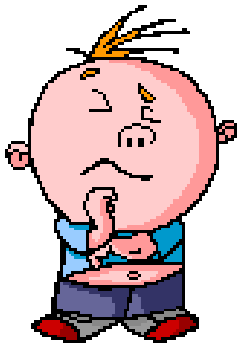
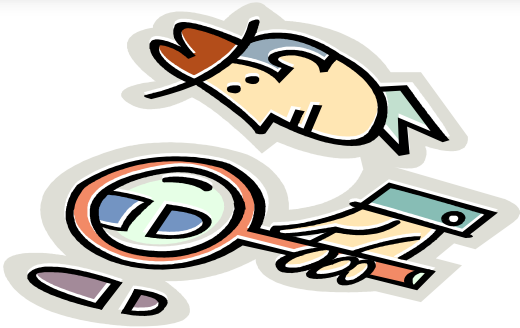


Follow the Units



- Units are clues
  - What does lbs/day/sq ft tell you?
- Per or “/” means divide
  - Answer = total pounds in a day divided by sq ft
- Convert given data to the units in the answer
  - Data given in flow, mg/l and diameter
  - Needs to be in pounds and square feet
- So to solve…
  - (10 MGD+9 MGD) x 8.34 x 2700 mg/l = 427,842 lbs/day
  - $(120 \text{ ft}/2)^2$ x 3.14 x 6 clarifiers = 67,824 sq ft
  - 427,842 lbs/day / 67,824 sq ft = 6.31 lbs/day/sq ft

Ignore the junk

- In most story problems…
  - Too much information
  - Distracting information
  - Hidden information
  - Statements that seem like a question
- Why is it there?
  - To see if you know what you are doing…
- Biggest mistake – use distracting info
- Cross out unneeded data

Back to the example:

- The Clean Water Wastewater Treatment Plant is converting from fixed film treatment to activated sludge. The CWWWT Plant Manager is interested in learning more so he visits a neighboring plant to see how they control their process. The CWWWT Plant Manager sees that the Bugville WWTP can use mass balance calculations to show how the sludge blanket levels will increase and decrease due to changes in diurnal flow conditions at the BWWTP. What is the % RAS rate in the afternoon?
- Use the data below to evaluate questions.
  - Morning influent flow rate 10 MGD (37,854 m3/day)
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  - MLSS = 2700 mg/l; MLVSS = 2250 mg/l; RAS = 7400 mg/l
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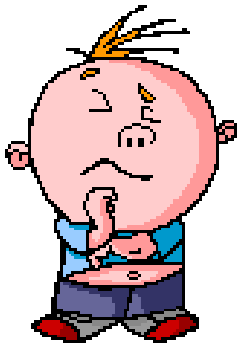

Ignore the junk

- Remember to work backwards
  - What is the question?
  - Calculate % RAS Rate @ afternoon flows
- What info do you need to answer the question?
  - Influent flow – make sure to pay attention to which one
  - RAS flow
- Biggest mistake? – use distracting info, like morning flow rate
- Cross out unneeded data – pretty much everything…

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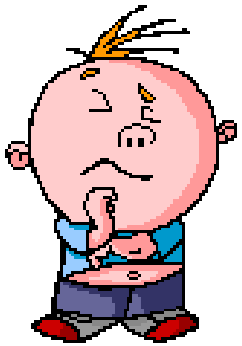

Write it down

- Write out the entire problem
  - Required for OEPA (and Operations Challenge)
  - Makes it easier to catch mistakes
  - Just like everything else in our world…if it isn't written down, it didn't happen…
- Easier to find mistakes
- Set up for crossing out units

MG	1,000,000	1 day	41,667 Gal
1 Day	1 Million	24 hour	Hour

Double check

- Did the answer make sense?
- Did you get an answer that is in the ballpark with the given answers?
  - Don’t stress if not exactly right…provided there isn’t another “close” one…
  - Double check your rounding and see if you can get closer
- Common mistakes
  - Time in fractions vs. minutes
  - Answers given in wrong increment (i.e. lbs/day vs. lbs/hr)
  - Answer greater than design criteria
  - Units are backwards (i.e. cu ft/lb vs. lbs/cu ft)
  - Stopping one step too short and picking the “right” wrong answer

Example – you're on your own…

The Buckeyeville WWTP serves a population of 11,250 which represents 4500 customer billing accounts billed quarterly. The WWTP is served by a lift station in the collection system and the collection system in general suffers from significant inflow and infiltration (I&I). As in the case of most communities, the City has ignored the operator's warnings about replacing infrastructure and now the main 36" gravity sewer line into the WWTP has collapsed. Raw sewage is overflowing upstream manholes, so the operator drags out his diesel powered trash pump in an effort to reduce the amount overflowed. The normal sewage flow to the Buckeyeville WWTP is a constant 1.5 MGD with no diurnal variations; however, it has been wet recently so the I&I impacts increase flows by 34%. The lift station is upstream of the collapse and has a circular shaped wet well that is 15 feet in diameter. The wetwell is 20 feet deep from the floor to the highest point without overflowing and causing a release to "waters of the state". The pumps shut off with 18 inches of sewage in the wetwell to prevent overheating of the submersible pumps. Only one-half of the WWTP's dry weather (i.e. no I&I) condition total flow goes through this station. The rest of the town flows by gravity to the WWTP. However, to reach the WWTP, all flows must go through the collapsed pipeline segment. If the operator needed to buy some time for additional pumps to get there, how much time would he have to utilize the lift station for storage thereby reducing the amount of sewage overflowed at the collapse? Assume the same I&I impacts as listed above and that the station is already drawn down to pump shut off level. The pumps are "locked out" and will not start while attempting to store sewage.

A: 18 Minutes B: 24 Minutes C: 35 Minutes D: 47 Minutes

On Your Own Example continues

- What is the question?
- What data do we need?
- Units?
- Write it down…
- Crunch the numbers
- Double check

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A: 18 Minutes B: 24 Minutes C: 35 Minutes D: 47 Minutes

Show the work

- Calculate the wetwell size
  - 20 ft deep – 18 inches at pump shut off or 20’ – 1.5’ = 18.5 ft deep
  - 15 ft in diameter
  - (15/2)2 x 3.14 x 18.5 x 7.48 gal/sq ft = 24,441 gallons capacity
- Calculate flow
  - 1.5 MGD to plant one half through L.S. and 34% increase due to I&I
  - (1.5 MGD x .34) + 1.5 MGD = 2.01 MGD
  - 2.01 MGD/2 = 1.005 MGD or 1,005,000 gallons per day
  - 1,005,000/1440 = 697.9 gpm
- Calculate HDT
  - 24,441 gallons / 697.9 gpm = 35 minutes
- Answer is C

Review

- Many reasons to improve your problem solving skills
- Use the steps
  - Work backwards
  - Follow the units
  - Ignore the junk
  - Write it down
  - Double check
- Most importantly…

…there WILL be a test later…

- For more information
  - http://www.epa.state.oh.us/ddagw/opcert.aspx
  - http://www.purplemath.com/modules/orderops.htm
  - http://www.wef.org/publications/page_wet.aspx?id=4690&page=ca&section=Logical Math

Discussion/Questions

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