Road Drainage

A Develop Understanding Task

Purpose: Determine the number of inlets needed throughout the project site of the proposed 4-lane highway to ensure a safe 8 ft spread for the width of discharge.

Career Field: Stormwater Engineering/Civil Engineering

SEPI, Inc.

WTCC Associate Program of Study and Contact Person:

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NC Math 4 Standards:

Include cluster headings

NC.M4.AF.1.1 Execute algebraic procedures to compose two functions.

NC.M4.AF.1.2 Execute a procedure to determine the value of a composite function at a given value when the functions are in algebraic, graphical, or tabular representations.

Unit Alignment:

Indicate where this lesson would be used in the course

NC Math 4 - Unit

- Unit 2

WTCC Math 171

- Evaluate Functions
- For a given function or set of functions in symbolic form, apply the operation of function division, as well as composition and decomposition.
- Given an output of a function, solve algebraically for the input.

Common Core State Standards for Mathematical Practice

Indicate which of the standards are highlighted in this lesson

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Prerequisite Skills

(addressed in the Launch Video/Desmos Activity)

- Converting units ((inches-acres)/hour to cubic feet per second)
- Sum notation $\sum$

- Evaluating Functions
- Solving Equations involving power functions with rational exponents
- Estimation of areas of specific regions in given photo (shaded differently) and stating what % each region is of the whole area & review of basic area formulas for geometric shapes

Time Required
The time required to complete this activity is approximately 90 minutes, plus launch video/Desmos: 30-40min.

Materials Needed
- Student Activity Sheet
- Calculator

The Teaching Cycle:
Launch (30-40 min): Desmos Activity with video embedded, usually assigned and due at start of class
Desmos Slide 1: SEPI, Inc. is a Civil Engineering firm headquartered in Raleigh, NC. In this activity, students will investigate how the design of inlets along a specific stretch of road relate to the total flow rate (and per inlet flow rate) for a given drainage area.

Desmos Slide 2: Launch Video

Desmos Slide 3: matching hydrology/stormwater engineering terms with definitions

Desmos Slide 4: Example Unit Conversions (easy first)

Desmos Slide 5: unit conversion (inches-acres)/hr to cubic feet/sec

Desmos Slide 6: summation notation (definition, examples, practice)

Desmos Slide 7: solve simple equations involving power functions and then more complex ones
Examples: 1. $3 = x^{0.4}$ 2. $5 = (0.27x^{0.37})/15$

Student Activity Sheet
Initial Discussion and Questions:
At the start of class, engage students in a discussion answering the following questions:
- Have you ever seen a road flood?
- When you observed this did all of the roads flood?
- Why did some flood when others did not?
- What factors contribute to whether a road floods or not?
- How does each factor contribute?
- Do they increase or decrease the likelihood of a flooded road?

Prediction:
On their own have students consider the following: knowing that the length of the road is 0.36 miles and this is a 50 acre drainage area, have the students make an educated guess on the number of inlets needed to control the spread of water on the highway. This will be compared with their final calculation at the end of the activity.

Explore Part 1 (45 minutes):
Divide students into groups of 3-4 and have them first work independently and then compare/discuss answers together and adjust individual findings as they see fit.

Part 1:
Circulate and monitor groups to ensure students are on the right track with the types of ground cover chosen for the drainage area photo given. Also check that the %'s found for each type of cover are reasonable and that the %'s add to 100%. Listen for good discussions when students compare findings. Remind them of their practice exercise in the Desmos Launch Activity, if needed.

For question 4, Examine the tables of runoff coefficients below. What do you notice about the values in the table? Is there a significance (relationship/connection) between the type of ground cover and the corresponding values? Guide each group to see that cover types with C values closer to 1 will allow closer to 100% runoff (lower absorption rate), and cover types with C values closer to 0 will allow closer to 0% runoff (higher absorption rate). If students are having a hard time determining the relationship between the numbers in the table and the type of ground cover, ask them to describe what each would feel like or look like. Ask them to talk about what happens when it rains on each of the types of surface.

Students will need to apply the correct weighted coefficient function for question 4. Circulate and monitor groups to ensure students are on the right track. Students may need guidance in understanding the concept of sigma notation. Look for students who add the area values and the coefficient values and then find the product of those sums. Remind students of PEMDAS if this error occurs. If students are struggling, remind the students of the Desmos Launch Activity problems for sigma notation.

Discuss Part 1 (10 minutes):
Once the groups have completed part 1, initiate a whole class discussion in which you ask students from different groups to:

- share their estimates for questions 1 and 2, and their reasoning behind their choices
- ask students to explain whether they decided to keep their answers for questions 1 and 2 or if they adjusted based on their group discussion
- ask students to share their answers to questions 4-6 as well. Highlight the different ways students interpret the numbers

Despite their differences in estimations in part 1, there should not be much variation in their runoff coefficient values. If there is, dig into why this happened as a class.

Explore Parts 2 and 3 (25 minutes):
Students will need to apply the correct total rate of discharge function for question 4.

$$Q_T = C_W \cdot i \cdot A$$

Cfs (**c**ubic feet per **s**econd) is an alternate expression for $\frac{ft^3}{s}$.
Industry standard applications do not require units of measure to match up exactly due to insignificant differences in decimal values. This shows up with the C_W runoff coefficient formula and the Q_T total discharge formula. Some students may try to convert inches-acres/hr to cfs and see that it doesn't exactly convert (but very close). For just these students, mention that they are working with water and units will never be exact.

Discuss Parts 2 and 3 (10 min): In groups, have students compare inlet flow rates found and their solution steps for solving the equation containing composition with power function. Students can then help each

other catch errors and correct as needed. Circulate among groups and monitor the discussion about the meaning of Q.

Next, as a class, have students give their predicted number of inlets needed for the project and the number of inlets needed based on their calculations. The calculated number of inlets should be similar amongst groups. If not, have the different groups explain how they arrived at their final answers. Ask students to explain how they determined their initial predicted number of inlets as well.

Exit Ticket: Answer the following questions:

- What is at least one new thing that you learned today?
- What is at least one thing you still have questions about?
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Answer Key: Best student work- use as an example to share with whole class (with permission) and note that individual findings could vary slightly for weighted runoff coefficients (and %'s of each cover type identified in drainage area)